# A HYBRID FRAMEWORK FOR ASSESSING THE COST OF ROAD TRAFFIC CRASHES IN SOUTH AFRICA

by

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# DECLARATION

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**A HYBRID FRAMEWORK FOR ASSESSING THE COST OF ROAD TRAFFIC CRASHES IN SOUTH AFRICA**

I declare that the above thesis is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

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# ABSTRACT

Road traffic crashes are one of the worst risks of road mobility worldwide, representing a huge socio-economic problem particularly in developing countries such as South Africa. In order to provide a sound economic basis for investment decisions to address this challenge, it is critical to assess the cost of these crashes. These estimates serve cost-benefit analysis inputs to facilitate a more efficient resources allocation for interventions to address the challenge posed by road crashes. South Africa has not been updating crash cost estimates on a regular basis, and those that were conducted used the much criticised human capital approach. Therefore, the available estimates could not be relied upon for planning purposes and comparison with the estimates of other countries.

It is against this background that this study developed and illustrated the application of a hybrid framework for assessing the cost of road traffic crashes in South Africa. The framework uses the human capital approach and the willingness-to-pay approach in one study. Human capital approach cost estimates are needed to inform planning to maximize the national output, while the willingness-to-pay estimates are more suitable when the main concern is to inform interventions to increase social welfare by reducing injuries and fatalities. The willingness-to-pay approach uses the contingent valuation and the stated preference methods. A survey questionnaire with contingent valuation and stated preference questions was administered in two phases to a sample of 273 respondents within the transport industry. For the human capital approach, the cost estimates in the 2016 Cost of Crashes in South Africa report were adjusted for inflation using the 2017 rate of 5.3% to obtain 2017 cost estimates.

This study revealed that the human capital approach underestimates the cost of road crashes. The study contributes to the body of knowledge by using the human capital approach and the willingness-to-pay approach in one study to illustrate the applicability of this hybrid/ combination within the South African context. Future research needs to replicate this study on a sample drawn from all nine provinces of South Africa, so that the cost estimates are representative of the country’s population.

**Key terms:**

Cost of road traffic crashes, human capital approach, willingness-to-pay approach, contingent valuation method, stated preference method, value of a statistical life, value of accident risk reduction, cost of life loss, cost–benefit analysis, cluster analysis, binary regression model.

# NKATSAKANYO

Mitlumbo ya mifambafambo ya le magondzweni i xin'wana xa miringeto (*risks*) yo biha ku tlula hinkwayo ya swifambo swa le gondzweni emisaveni hinkwayo, leswi yimelaka xiphiqo lexikulu xa swohanyaswin'we-ikhonomi ngopfu-ngopfu eka matiko lama ya ha hluvukaka tanihi Afrika-Dzonga. Ku va ku nyikiwa masungulo yo tiya ya xiikhonomi eka swiboho swa mbekiso ku tirhana na ntlhontlho lowu, i swa nkoka swinene ku hlela ndhurho wa mitlumbo leyi.  Mipimanyeto leyi yi tirha tanihi nxopaxopo wa swinghenisiwa swa mbuyelo wa ndhurheriwo ku endlela ku kuma mphakelo wa switirhisiwa wo tirha kahle eka ku nghenelela eka ku tirhana na mitlhontlho leyi vangiwaka hi mitlumbano ya le magondzweni.  Tiko ra Afrika-Dzonga a ri nga ri ku pfuxeteni ka mahungu ya mipimanyeto ya midurho ya mitlumbano ya le magondzweni nkarhi na nkarhi, naswona leyi a yi endliwa a yi tirhisa maendlelo lamo soriwa ngopfu yo languta nkoka wa vanhu (*human capital*). Hikwalaho, mipimanyeto leyi nga kona a yi nga ta va leyi tshembekakaka eka ku kunguhata na ku pimaniseka na mipimanyeto ya matiko man'wana.

Hi le ka ku landzelela vundzhaku lebyi laha dyondzo leyi yi nga tumbuluka na ku kombisa matirhiselo ya rimba ra ntirho wo katsa (*hybrid*) ku kambela ndhurho wa mitlumbo ya swifambo swa le magondzweni eAfrika-Dzonga. Rimba leri ri tirhisa endlelo ro kongomisa eka nkoka wa vanhu na ku pfumela ku hakela (*willingness-to-pay*), eka dyondzo yi ri yin'we. Mipimanyeto ya midurho ya nkoka wa vanhu ya laveka ku va yi pfuna eka ku kunguhata leswaku yi tlakusa swinenenene swihumesiwa swa rixaka, loko hala tlhelo mipimanyeto yo pfumela ku hakela yona yi ri yona yi fanelaka swinene eka ku pfuneta minghenelelo yo tlakusa nhlayiseko wa vanhu hi ku hunguta ku vaviseka na ku fa. Endlelo ro pfumela ku hakela ri tirhisa maendlelo ya swo ka swi nga ri swa makete (*contingent valuation*) na ya maendlelo yo langa (*preference*). Khwexinere yo valanga leyi a yi ri na maendlelo yo ka ya nga ri ya swa makete na swilangiwa leswi a swi boxiwile, yi tirhisiwile hi magoza mambirhi ku sampula vaanguri va 273 eka ntirho wa swo tleketla. Eka mhaka ya endlelo ro kongomisa eka nkoka wa vanhu, mipimanyeto ya ndhurho eka xiviko xa 2016 xa *Cost of Crashes in South Africa* yi hundzuluxiwile hi ku katsa inifulexini, ku tirhisiwa mpimo wa 2017 wa 5.3% ku kuma mipimanyeto ya ndhurho ya 2017.

Dyondzo leyi yi paluxile leswaku endlelo ro kongomisa eka nkoka wa vanhu ri kayiveta ku vona ndhurho wa mitlumbo ya le magondzweni. Dyondzo leyi yi hoxa xandla eka ntsengo

wa vutivi hi ku tirhisa endlelo ro languta nkoka wa vanhu na endlelo ro pfumela ku hakela eka dyondzo yi ri yin’we ku kombisa ntirhiseko wa endlelo leri ra nkatso (*hybrid*)/nhlanganiso eka xiyimo xa Afrika-Dzonga. Ndzavisiso wa nkarhi lowu taka wu fanele ku engeta dyondzo leyi hi sampulu leyi humaka eka swifundzakulu hinkwaswo swa nkaye swa Afrika-Dzonga, leswaku mipimanyeto ya ndhurho yi yimela vanhu va tiko hinkwaro.

**Mathemekulu:**

Ndhurho wa mitlumbo ya mifambafambo ya le magondzweni, endlelo ro languta nkoka wa vanhu, endlelo ro pfumela ku hakela, endlelo ro ka ri nga yi hi swa makete, endlelo ra milango leyi boxiweke, nkoka wa vutomi bya swa tinhlayohlayo, nkoka wo hunguta ndzingeto wa makhombo, ndhurho wa ndzahleko wa vutomi, nxopaxopo wa mbuyelo wa ndhurheriwo, nxopaxopo wa nkatso, modlele wa swicinceki swimbirhi.

# OKUCATSHANGIWE

Ukuphazamiseka komgwaqo kungenye yezingozi ezimbi kakhulu zokuhamba komgwaqo emhlabeni jikelele, ezimele inkinga enkulu yenhlalo nezomnotho ikakhulukazi emazweni asathuthuka njengeNingizimu Afrika. Ukuze unikeze isisekelo sezomnotho esizwakalayo ezinqumeni zokutshala izimali ukubhekana nale nselele, kubalulekile ukuhlola izindleko zalezi zingozi. Lezi zilinganiso zisebenza njengeziphakamiso zokuhlaziywa kwezindleko zokuhlomula ukuze kube lula ukunikezwa kwezinsiza ezenzelwe ukuxazulula inselele ebangelwa ukuphazamiseka komgwaqo. INingizimu Afrika ayizange ibuyekeze ukulinganisa izindleko zezingozi njalo, futhi lezo ezenziwa zisebenzise indlela enkulu yokugxeka ukusebenzisa abantu. Ngakho-ke, izilinganiso ezitholakalayo azikwazanga ukuthenjelwa kuzona ngezinjongo zokuhlela nokuqhathaniswa nezilinganiso zamanye amazwe.

Lokhu kuphikisana nalesi sigaba ukuthi lolu cwaningo lusungulwe futhi luboniswe ukusetshenziswa kohlaka oluxubile lokuhlola izindleko zokuphazamiseka komgwaqo eNingizimu Afrika. Uhlaka lusebenzisa indlela yokusebenzisa abantu kanye nendlela yokuzimisela-ukukhokha ocwaningweni olulodwa. Ukulinganiselwa kwezindleko zokusebenzisa abantu kuyadingeka ukuze kwaziswe ukuhlela ukwandisa umkhiqizo kazwelonke, kanti ukulinganiselwa kokuzimisela-ukukhokhela kukulungele kakhulu ukwazisa ukungenelela ukwandisa inhlalakahle yomphakathi ngokunciphisa ukulimala nokubulawa kwabantu. Indlela yokuzimisela-ukukhokha isebenzisa ukuhlaziywa kwesilinganiso kanye nezindlela okukhethwa ngazo. Imibuzo yokuhlola ngokuhlaziywa kwesilinganiso kanye nemibuzo ekhethwe ngayo yenziwa ngezigaba ezimbili embonakalisweni yabaphendulile abangama-273 embonini yezokuthutha. Ngokwendlela yokusebenzisa abantu, izindleko ezilinganiselwa ku-2016 Izindleko Zokushayisana eNingizimu Afrika kubikwa ukuthi zalungiselwa ukwenyuka kwamandla emali, kusetshenziswa isilinganiso sango-2017 esingu-5.3% ukuthola izindleko zango-2017.

Lolu cwaningo luveze ukuthi indlela yokusebenzisa abantu ithatha kancane izindleko zokuphazamiseka komgwaqo. Ucwaningo lunomthelela emzimbeni wolwazi ngokusebenzisa indlela yokusebenzisa abantu kanye nendlela yokuzimisela-ukukhokha ocwaningweni olulodwa ukukhombisa ukufaneleka kwalesi sivumelwano / inhlanganisela ngaphakathi komongo waseNingizimu Afrika. Ucwaningo lwesikhathi esizayo ludinga ukuphindaphinda lolu cwaningo embonakalisweni othathwe kuzo zonke izifundazwe eziyisishiyagalolunye zaseNingizimu Afrika, ukuze ukulinganiswa kwezindleko kummele abantu bezwe.

**Amagama asemqoka:**

Izindleko zokuphazamiseka komgwaqo, indlela yokusebenzisa abantu, indlela yokuzimisela-ukukhokha, indlela yohlaziywa kwesilinganisa, indlela ekhethwa ngayo, ukubaluleka kokuphila kwamanani, Ukubaluleka kokunciphisa izinhlekelele, izindleko zokulahleka kokuphila, ukuhlaziywa kwezindleko-nzuzo, ukuhlaziywa kwamaqoqo, Isifaniselo sokulawula kanambambili

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ADB: | Asian Development Bank |
| BITRE: | Bureau of Infrastructure, Transport and Regional Economics |
| BRICS: | Brazil, Russia, India, China and South Africa |
| CBA: | cost–benefit analysis |
| C-BRTA: | Cross-Border Road Transport Agency |
| CEO: | Chief Executive Officer |
| CPI: | Consumer Price Index |
| CSIR: | Council for Scientific and Industrial Research |
| CSS: | Central Statistics Services |
| CV: | contingent valuation |
| CVM: | contingent valuation method |
| DoT: | Department of Transport |
| EMPD: | Ekurhuleni Metropolitan Police Division |
| EMS: | Emergency Medical Services |
| GBD: | Global Burden of Disease |
| GDP: | gross domestic product |
| GFIP: | Gauteng Freeway Improvement Project |
| HC: | human capital |
| HCA: | human capital approach |
| iRAP: | International Road Assessment Programme |
| IRTAD: | International Traffic Safety Data and Analysis Group |
| JMPD: | Johannesburg Metropolitan Police Division |
| MAIS: | maximum abbreviated injury scale |
| MNL: | multinomial logit |
| MVA: | motor vehicle accident |
| NDoT: | National Department of Transport |
| NITRR: | National Initiative for Transport and Road Safety Research |
| NRSC: | National Road Safety Council |
| OBPR: | Office of Best Practice Regulation |
| OECD: | Organisation for Economic Co-operation and Development |
| PDO: | property damage only |
| PIAT | Road Traffic Incident Investigation Program |
| QALY: | quality adjusted life year |
| RAF: | Road Accident Fund |

ROI: return on investment
RPM: revealed preference method
RSR: Railway Safety Regulator
RTC: road traffic crash
RTIA: Road Traffic Infringement Agency
RTMC: Road Traffic Management Corporation
SA: South Africa
SANRAL: South African National Roads Agency Limited
SAPS: South African Police Service
SD: standard deviation
SP: stated preference
SPM: stated preference method
SPSS: Statistical Package for Social Sciences
SweRoad: Swedish National Road Consulting AB
SWOV: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid (Institute for Road Safety Research)
TAC: Transport Accident Commission
TRL: Transport Research Laboratory
UIB: uniform investigation branch
Unisa: University of South Africa
US$: United States Dollar
USA: United States of America
VoSL: Value of a Statistical Life
VPF: value of preventing a fatality
VPSF: value of preventing a statistical fatality
WHO: World Health Organization
WtP: willingness to pay
WtPA: Willingness-to-Pay Approach

# CHAPTER 1:
# INTRODUCTION TO THE STUDY

## 1.1 BACKGROUND TO THE STUDY

Road crashes are one of the worst side-effects of road mobility worldwide; thus, representing a huge socio-economic problem. This is especially true in the case of developing countries (Abdallah, El Hakim, Wahdan & El Refaeye, 2016:10; Alrukaibi, Alotaibi & Almutairi, 2015:46; Bora, Landge & Dalai, 2018:1275; Iragüen, De Dios Ortùzar, 2004:513; Kittelson, 2010:1; Mohamed, 2015:43; Pėrez-Nûńez, Pelcastre-Villafuerte, Hijar, Avila-Burgo & Celis, 2012:69; Rizzi & De Dios Ortúzar, 2006b:471 & Yusoff, Mohamad, Abidin, Nor & Salleh, 2013:1), of which South Africa is one. Road traffic crashes have become a growing public health problem and a large welfare loss to society, which threatens the lives of many people around the world (Akgüngör, 2007:119, Ismail & Abdelmageed, 2010:220; Jou & Chen, 2015:1; Kudebong, Wurapa, Nonvignon, Norma, Awoonor-Williams & Aikins, 2011:135; Racioppi, Eriksson, Tingvall & Villaveces, 2004; Swedish Civil Contingencies Agency, 2012:4). Furthermore, road crashes impose intangible, financial and economic costs to society, such as reduced quality of life, reduced productivity, medical and other resource costs (New Zealand Ministry of Transport, 2015:iii). Road crashes[1] happen in a fraction of a second but their consequences may last for days, months, years or even the rest of the person's life. In addition to loss of life or reduced quality of life, road crashes lead to many other consequences for the survivors, such as legal implications, an economic burden, home and vehicle adaptations as well as psychological consequences (European Transport Safety Council, 2007:18). Research conducted by the Asian Development Bank (n.d.:1) summarises the consequences of road traffic crashes as follows:

> Transportation accidents, whether road, rail, air, river, or sea accidents, have undesirable consequences. The negative economic and social impacts on accident victims and their families and friends, as well as on nations, are considerable. However, until recently, road transportation accidents, unlike rail or air transportation accidents, have not been given much public attention, because road accident casualties come in ones and twos, while casualties from rail and air transportation accidents, which are less common, come in large numbers.

[1] A road traffic crash is an event that produces injury and/or property damage, which involves a vehicle in transport, and occurs on a road or while the vehicle is still in motion after running off the road (Bhalla, Shahraz, Bartels & Abraham, 2009:239). The term 'crash' instead of 'accident' is used to illustrate that collisions are generally avoidable and not the result of chance events (Bureau of Infrastructure, Transport and Regional Economics [BITRE], 2009:2; Risbey, Cregan & De Silva, 2010:1).

According to the 2018 Global Status Report on Road Safety (World Health Organization [WHO], 2018:5), globally, more than 1.35 million people die each year as a result of road crashes, making road traffic injuries a leading cause of death in the world (Antoniou, 2014:31 & Ericson & Kim, 2011:210; World Health Organization [WHO], 2018:5). A disproportionate number of these deaths occur in low- and middle-income countries where rapid population and economic growth have been accompanied by increased motorisation and road traffic injuries (Abdallah et al., 2016:10; Atubi & Gbadamosi, 2015:136; Bora et al., 2018:1275; Bener, 2005:45; Sapkota, Bista & Adhikari, 2016:1; World Bank, 2008:1; WHO, 2015:ix). Sustained economic growth is reported to be a leading factor in the increasing motorisation in Brazil, Russia, India, China and South Africa (BRICS), mainly through two mechanisms, namely increasing per capita income and increasing urbanisation (Hyder & Vecino-Ortiz, 2014:423). Furthermore, in areas with sustained economic growth, vehicle fleet growth generally outpaces the growth of the institutions and resources needed to maintain road safety and road infrastructure (Duddu & Pulugurtha, 2013:585; Hamdan & Daud; 2014:1051; Hyder & Vecino-Ortiz, 2014:423; Roberts, 2012:8). It is reported that over 91% of the world's road fatalities occur in low- and middle-income countries, which only contribute about 50% of the world's vehicle population (Abdallah et al., 2016:10; Parkinson, 2013:v). Rizzi and De Dios Ortúzar (2006b:473) attribute the high rate of road crash injuries in developing countries to the fact that road systems in these countries are far from mature and as a result, hundreds of thousands of fatalities (as well as many more seriously injured victims) are experienced every year. Globally, road traffic crashes are not just a huge social problem and a major cause of death, but also a leading cause of disability (Abdallah et al., 2016:10; Bener, 2005:45; Carnis & Achit, 2014:350).

Road traffic injuries are both a public health problem and a developmental issue (Miranda et al. & Road Traffic Incident Investigation Program [PIAT] Working Group, 2014:1; Razzak, Bhatti, Ali, Khan & Jooma, 2011:199). For example, low- and middle-income countries lose approximately 3% of their gross domestic product (GDP) as a result of road traffic crashes (Mohan, 2002:4). In support of this assertion, in a study conducted in Metro Manila in the Philippines, De Leon, Cal and Sigua (2005:3183) found that road vehicle crashes are a health, social and economic problem because:

- the health sector would have to stretch its bed capacity in order to care for victims while still overseeing other important illnesses;
- families are displaced and their future ruined as a result of the sudden death of their breadwinners, which is a social welfare problem; and
- road crashes lay off workers, which eventually translates to millions of rands of potential lost productivity, affecting domestic production and the economy at large.

Abdallah et al. (2016:10) assert that many road crashes are preventable and by preventing them, society would increase the supply of scarce resources that can be used to increase income and improve welfare. Research was therefore needed to assess the cost of road traffic crashes for use in cost–benefit analysis (CBA), sometimes called benefit costs analysis, to facilitate a more efficient allocation of the resources of society, particularly for use in the implementation of intervention programmes to address the road safety challenge outlined above (Boardman, Greenberg, Vining & Weimer, 2011:32).

Road traffic crashes result in four main outcomes, namely fatalities, serious injuries, minor injuries and property damage only as depicted in Figure 1.1 below.

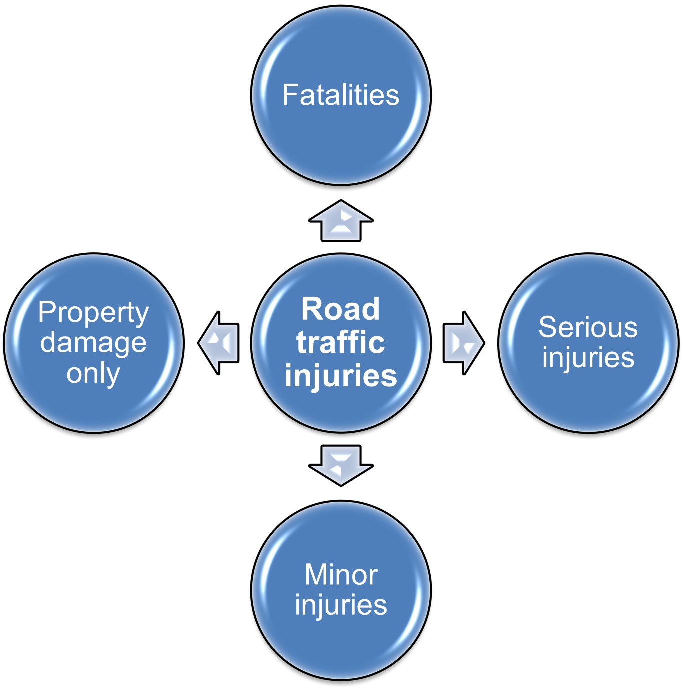


**Figure 1.1: Road traffic crash outcomes**

Source: Adapted from Bhalla et al. (2009:241) and Hejazi, Shamsudin, Radam, Rahim, Ibrahim and Yazdani (2013:152).

In South Africa, research by De Beer and Van Niekerk (2004:1) posits that road traffic crashes have an enormous effect on the South African society in terms of human loss, pain and suffering, and cost to the economy and the individual. According to the WHO, approximately 16 000 people die every day worldwide from all types of injuries, and injuries represent 12% of the global burden of disease thus making injuries the third most important cause of overall mortality (World Health Organization [WHO], 2004:3-4). Deaths from traffic crash injuries form a very significant part of the problem, accounting for 25% of all deaths from injury (European Transport Safety Council, 2007:8). In line with these global trends, South Africa loses an average of over 13 500 people to road crashes per annum, which translates into an average of 37 fatalities per day (Department of Transport [DoT], 2015). Road traffic statistics for fatal crashes and fatalities for South Africa for a 5-year period, 2013 to 2017, are summarised in Figure 1.2.

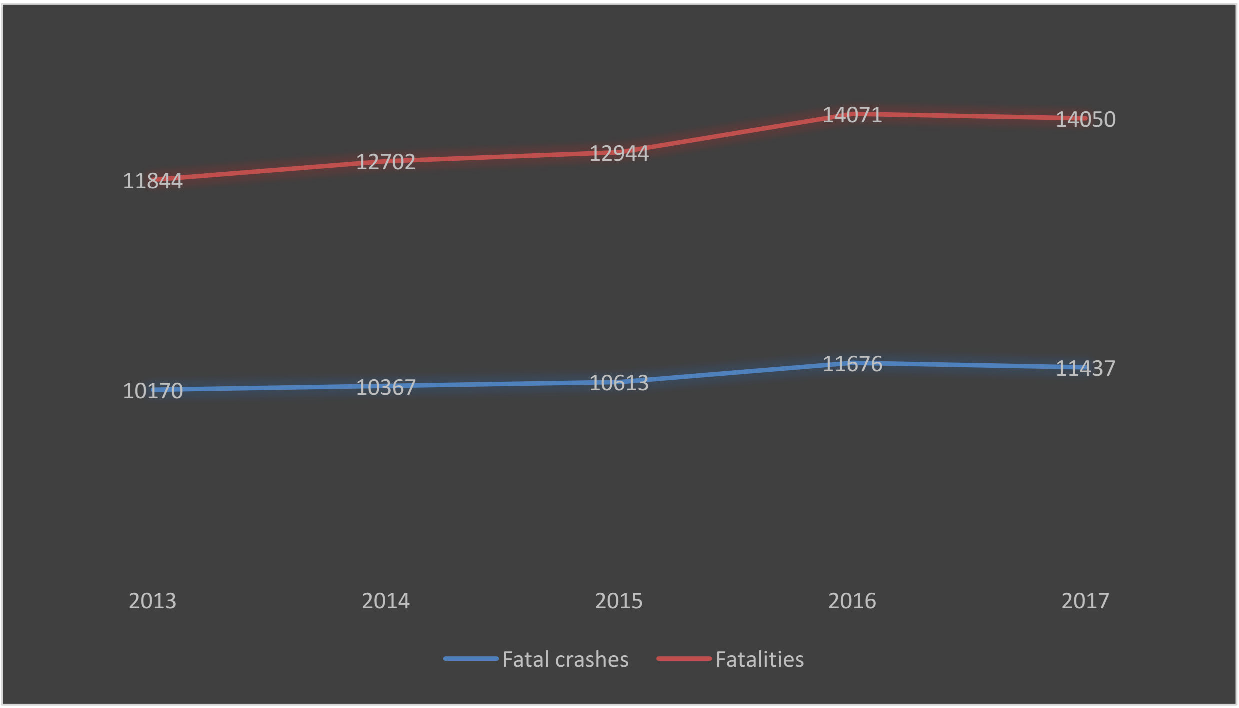


**Figure 1.2: Fatal crashes and fatalities for the years 2013–2017**

*Source: Adapted from Department of Transport (2015:17)*

It is against the background outlined above that making critical decisions, such as investing in traffic safety, developing and improving road infrastructure or distributing research priorities and any other activities required to strengthen road safety, requires either implicitly or explicitly the evaluation and estimation of the costs of these incidents in order to make sure that those investments are economically feasible considering that economic resources are limited (Mohamed, 2015:43). In support of this assertion, Ahadi and Razi-Ardakani (2015:164) further posit that road traffic crashes and their subsequent effects are increasing dramatically. Estimating their cost could therefore be a vital step in improving the recognition of this problem.

Furthermore, the Council for Scientific and Industrial Research (CSIR) has been estimating the South African unit cost of road traffic crashes periodically since 1962. Table 1.1 shows the various authors, year of road crash data used for each study as well as the year the study was conducted and published.

**Table 1.1: Previous studies to determine cost estimates of road crashes in South Africa**

| Author(s) | Base year | Date of publication | Costing approach |
|---|---|---|---|
| Burton and Eksteen | 1963 | 1967 | Human capital |
| Cillié | 1972 | 1975 | Human capital |
| Cillié and Freeman | 1975 | 1977 | Human capital |
| De Beer and Van Niekerk | 2002 | 2004 | Human capital |
| De Haan | 1991 | 1992 | Human capital |
| De Vos and Burton | 1962 | 1965 | Human capital |
| Glass and Hamilton | 1986 | 1987 | Human capital |
| Goosen | 1979 | 1980 | Human capital |
| Goosen and Kolman | 1980 | 1982 | Human capital |
| Labuschagne | 2015 | 2016 | Human capital |
| Morden | 1988 | 1989 | Human capital |
| Schutte | 1998 | 2000 | Human capital |
| Verburgh, Farquharson and Hamilton | 1984 | 1985 | Human capital |

Table 1.1 indicates that, from 2003 to 2014, no study was conducted in South Africa to update the estimates of costs of road traffic crashes in South Africa. This is despite the fact that the scale and magnitude of the effects of road crashes on the lives of the people involved and society in general must be clearly defined for purposes of raising awareness and as an input to the planning and evaluation of government's road safety intervention measures (De Leon et al., 2005:3183). The potential implication is that for the thirteen years during which no estimates had been determined, there was arguably limited scientific basis that informed the planning and evaluation of road safety measures in the country to the extent which is needed (Labuschagne, 2016:i). Therefore, allocation of resources for road safety measures implemented over the same period (2003–2014) was done with relatively limited basis.

South Africa is a signatory of the United Nations Decade of Action for Road Safety 2011–2020 (World Health Organization [WHO], 2011), which means the country is regarded as a global role player. As a result, in order to ensure comparability of cost estimates, approaches used in the assessment of the costs of road crashes need to be similar to the ones used by other signatory countries, such as New Zealand, Sweden, Singapore, Egypt, Belgium, United Kingdom and Australia, amongst the other more than 100 signatory countries. Despite many developments globally around approaches used in the estimation of the cost of crashes, South Africa used the human capital approach (HCA) (Burton & Eksteen, 1967; Cillié, 1975; Cillié & Freeman, 1977; De Beer & Van Niekerk, 2004; De Haan, 1992; De Vos & Burton, 1965, Glass & Hamilton, 1987; Goosen, 1980; Goosen & Kolman, 1982; Labuschagne, 2016; Morden, 1989; Schutte, 2000; Verburgh, Farquharson & Hamilton, 1985) for all the crash costing studies listed in Table 1.2. Many countries advocate for the use of the willingness to pay approach (WtPA) (see Perovic & Tsolakis, 2008) instead of the HCA while others such as Australia have enhanced the HCA to be a hybrid approach that also considers pain and suffering; thus, combining elements of the HCA and those of the WtPA (BITRE, 2009:22). It is against this background that previous studies (such as Giles, 2003; Perovic & Tsolakis, 2008) assert that an important conceptual advance in the state of practice of road safety valuation was achieved in the 1980s by valuing road safety according to subjective preferences rather than by using the heavily criticised HCA (Hensher, Rose, De Dios Ortúzar & Rizzi, 2009:692).

South Africa also started including the pain and suffering cost component from the study conducted by Morden (1989) onwards including in the more recent study by Labuschagne (2016). The pain, grief and suffering cost is associated with compensation paid to a road crash victim or family and relatives for loss of quality of life, anxiety, trauma, anguish and other forms of post-traumatic stress disorders (BITRE, 2009:28).

It is against this background that the problem statement is discussed.

## 1.2 PROBLEM STATEMENT

Road traffic crashes impose a substantial burden on society in terms of human loss, pain and suffering, as well as cost to the economy and the individual (Bhalla, 2013:13). Bhalla (2013:13), for instance, found that road crashes result in economic losses equivalent to between 1.5% and 2.9% of the GDP in Argentina, between 1.8% and 3.5% in Mexico, and between 2.0% and 3.9% in Paraguay. Therefore, estimates of the economic costs imposed by road traffic crashes on society could provide policymakers with an important indicator for allocating appropriate investments to road safety through evidence-based policymaking. These estimates could also be useful inputs in national road safety policy dialogue thus supporting the building of strong business cases for road safety investments based on cost-effectiveness and cost–benefit analyses (Bhalla, 2013:8; Bliss & Breen, 2009:11; Wijnen & Stipdonk, 2016:97).

Road crash costing[2] is necessary because as indicated earlier (see 1.1), road crashes impose a substantial burden on society. Despite the importance of assessing road crashes as explained previously, limited research on the assessment of the cost of road traffic crashes in South Africa was undertaken between 2002 and 2014. However, scarce resources (such as financial and human resources) mean that policymakers have to prioritise among different investments towards road safety in order to reduce the number of seriously injured victims or fatalities (González et al., 2017:2). Therefore, information about the costs of road crashes is important for evidence-based policymaking since it provides insight into the consequences of road crashes for the economy and social welfare (Wijnen & Stipdonk, 2016:97). Furthermore, all the studies conducted in South Africa since 1965 only used the HCA, which is contrary to practices globally, which have seen a shift by many countries to adopt the WtPA in estimating the cost of crashes (Giles, 2003:95). This, in part, confirms Bhalla's (2013:48) assertion that road safety ranks low among national health and development priorities even though the large public health burden of traffic crashes has been known since the mid-1990s when results from the first Global Burden of Disease (GBD) Study (Bhalla, 2013) were published.

In the South African (SA) context, the following is evident. Planning and allocation of resources for road safety programmes over the thirteen-year period during which cost estimates were not updated or done were based on outdated information from the 2004 study (De Beer & Van Niekerk, 2004). The latter could not be relied on any more for resource allocation decisions and road safety programme evaluation since it was not based on recent input data and parameters, incorporating current international best practice. Furthermore, unreliable input data used in decision-making, policy formulation and economic analysis of transport projects, amongst others, give rise to unreliable outcomes. However, in order to prioritise public expenditure on road crash prevention and injury reduction programmes, governments need information on these costs as well as the estimated benefits of the proposed programmes (Giles, 2003:96). In order for South Africa to ensure comparability at international level, the cost estimates need to be assessed using similar approaches as used by most if not all other countries globally.

The Road Accident Fund's (RAF) formula for calculating crash victim compensation in South Africa comprises medical costs, loss of earnings and support, funeral costs and general as well as RAF and claimants' legal costs culminating in a total cost of R36.4 billion and R25.4 billion in 2014 and 2013, respectively (RAF, 2014:86). This indicates that the RAF also uses the HCA to calculate compensation focusing particularly on direct costs. However, BITRE

[2] Road crash costs are the estimated economic and social effect of road traffic crashes (Mohamed, 2015:47).

(2009:21) as well as Perovic and Tsolakis (2008:802, 805 & 806) identify the main shortcoming of the HCA as understating the human costs of road crashes. Furthermore, in 2013, the Road Traffic Management Corporation (RTMC) with the assistance of the International Road Assessment Programme (iRAP) found about R306 billion as the total road crash cost in South Africa for that year. There are however no details regarding the variables that iRAP considered to arrive at this figure. In summary, an assumption is made that all road crash cost assessment studies conducted in South Africa only use the HCA despite a shift by most countries towards using the WtPA in crash cost estimation. This is further confirmed by the 2016 Cost of Crashes study commissioned by the RTMC (see Labuschagne, 2016), which still employed the HCA, despite the strong criticisms levelled against it.

It needs to be emphasised from the onset that evaluation of the cost of road crashes is not an exact science (Perovic & Tsokalis, 2008:802). As a result, several approaches have been formulated and applied; yet there is no one unique approach that is unanimously accepted (Perovic & Tsokalis, 2008:802). In particular, Alrukaibi et al. (2015:46) and Ahadi and Razi-Ardakani (2015:164) identify six approaches that are used in road crash cost assessment, namely gross output or HCA, net output approach, life insurance approach, court award approach, implicit public sector valuation approach, and value of risk change or the WtPA. These approaches are explained in detail in Chapter 2.

Despite the many approaches, there are only two established approaches for evaluating costs of road traffic crashes that are commonly used, namely the human capital (*ex post* or after the fact) approach (HCA) and the willingness to pay (*ex ante* or before the fact) (WtPA) approach. The HCA estimates the cost of road traffic crashes as the lost earnings endured by casualties, whereas the WtPA estimates this cost as the amount individuals are willing to pay for reducing the risk of experiencing a road traffic crash (Ismail & Abdelmageed; 2010:222). According to Perovic and Tsolakis (2008:804):

- The HCA is described as “resting on accounting principles and the benefit of avoiding a premature death is given by the present value of the income flow the economy could lose as a result of the death”; and
- The WtPA values society’s willingness to pay for avoiding death, injury and damage outcomes from road crashes (See Figure 1.1 on the outcomes of road crashes).

It is against this background that a gap in research to provide internationally comparable estimates of the costs of road traffic crashes in South Africa was identified. It is crucial to apply the commonly used approaches to estimate the exact cost of road traffic crashes in South Africa, particularly those used by countries that have proved that they had the best practice models in the field of road traffic crash assessment. The HCA is however criticised for not necessarily supporting an efficient allocation of scarce resources to road safety and infrastructure projects as well as the inherent undervaluation of life for such groups as children and the elderly who do not contribute relatively much to economic output (see Wren & Barrell, 2010:15) whereas the WtPA is strongly applauded as the most feasible methodology for road crash cost valuation purposes since it values the small changes in probability of injury or death that an individual could gain from a road safety intervention (Perovic & Tsolakis; 2008:802, 805–806). Amongst other criticisms levelled against the HCA, BITRE (2009:21) also indicates that the HCA is at odds with a basic tenet of welfare economics that the valuation of losses due to premature death should generally reflect the individuals' preferences, that is this approach measures earning capacity but it does not measure how much the deceased value his or her own life. In the recent years there has consequently been a re-focus on the valuation of a statistical life from the *ex post* HCA to an *ex ante* WtPA, which is in part a recognition that there is a need to focus on establishing the amount, *ex ante*, that individuals are willing to pay to reduce the risk of exposure to circumstances that might lead to their death or degree of injury in the road environment (Hensher, Rose, De Dios Ortúzar & Rizzi, 2011:70).

Research by Ismail and Abdelmageed (2010:222) recommend that, if the main concern of a road crash cost assessment study is to inform planning to maximise the national output, the HCA is the appropriate approach for use, whereas the WtPA is more suitable when the main concern is to inform interventions intended to increase social welfare by reducing injuries and fatalities. Considering that both purposes are critical for the development of any country, it is critical that road crash assessment studies utilise both approaches to ensure that each crash cost valuation study conducted serves both purposes. The rationale of the current study was therefore to propose a hybrid framework for assessing road traffic crash costs in South Africa using both the HCA and the WtPA. The use of both approaches in one study has to ensure that road crash cost estimates of future studies can be used to inform planning, particularly resource allocation for interventions intended to maximise the national output as well as those intended to increase social welfare by reducing injuries and fatalities.

The contribution of the current study is threefold, namely at practical, theoretical and methodological levels. These three levels of contribution are dimensions of a best practice developed through this study in the form of a hybrid framework for assessing the cost of road traffic crashes in South Africa. The application of the framework will provide a state-of-the-art approach for use in the assessment of these costs. The use of these cost estimates can be summarised as:

- transport policy formulation;
- assessing the economic burden of road traffic crashes;
- economic analysis of transportation infrastructure projects;
- providing policymakers with an important indicator for allocating appropriate investments to road safety and infrastructure projects;
- viability and impact evaluation of crash reduction programmes;
- increasing the efficiency and equity of transport investment projects; and
- compensation of victims.

The next section outlines the objectives of the study.

## 1.3 RESEARCH OBJECTIVES

The primary and secondary objectives of this thesis are discussed below.

### 1.3.1 Primary research objective

The primary research objective of the study was to propose a hybrid framework for assessing the costs of road traffic crashes in South Africa (SA).

### 1.3.2 Secondary research objectives

In order to achieve the primary objective, the following secondary objectives were identified, namely to –

- provide a literature review on international best practice in the assessment of the cost of road traffic crashes;
- investigate the WtPA empirically in the SA context;
- determine the comparability of the cost estimates of the HCA and the WtPA; and
- structure the components of, and the relationship between, the HCA and the WtPA.

The next section discusses the research methodology that was employed in this study.

## 1.4 RESEARCH METHODOLOGY OF THE THESIS

This section provides an overview of the research methodology that was applied in this study, particularly in terms of the research design, population and sampling, data collection and analysis as well as reliability and validity. It needs to be indicated that the approach presented in this section is for illustrative purposes and therefore does not reflect the real case scenario of road crash cost in South Africa. A detailed discussion of these will be provided in Chapter 4 (section 4.5.2.2).

### 1.4.1 General

The sub-sections outline the research design, sampling, methodology (in terms of research instruments, data collection and analysis techniques that were employed in this study), and limitations of the study as well as ethical considerations.

### 1.4.2 Research design

The empirical investigation of the WtPA in the SA context used a descriptive quantitative research design. In particular, this research design answers the how, what, when, where and who questions since it was assumed that the target users of findings of these studies already know or understand the underlying relationships of the problem area (Tustin, Ligthelm, Martins & Van Wyk, 2010:86) (see section 4.5.2.2.1 for details on the research design).

### 1.4.3 Population and sampling

For the purpose of this study, the population consisted of employees of the Department of Transport (DoT), Cross-Border Road Transport Agency (C-BRTA), Railway Safety Regulator (RSR), RAF, Road Traffic Infringement Agency (RTIA) and RTMC. Babbie (2009:207) asserts that it is sometimes appropriate to select a sample on the basis of knowledge of a population, its elements and the purpose of the study. This type of sampling is called purposive sampling (or judgmental sampling). For the purpose of this study, a purposive or judgmental sample of 273 respondents was drawn from the study population, with a particular focus on employees at supervisory and management level. A stratified sample (see Cooper & Schindler, 2014:351-354) was therefore drawn to ensure representativeness of the sample across the employment levels of the different participants.

### 1.4.4 Primary data collection and analysis

In order to develop data collection instruments that could be used to collect data that would meet reliability and validity requirements, for the purpose of this study survey questionnaires relating to willingness to pay used in the following studies were adapted (Abdallah et al., 2016:14; Haddak, 2016:296, 298, 299; Haddak, Havet & Lefèvre, 2014:n.p.; Le, Van Geldermalsen, Lim & Murphy, 2011:4–5, 9; Muller & Reutzel, 1984:812). The willingness to pay (WtP) questionnaires were used to collect data on the demographic characteristics, travel behaviour as well as willingness to pay of respondents or road users to alleviate their risk of road traffic crash injury (see Annexures C and D for the adapted WtP questionnaires).

Once the WtP survey questionnaires (see Annexures C and D for the questionnaires) had been completed, the data was analysed using the SPSS statistics data analysis software.

### 1.4.5 Reliability and validity

One of the techniques used to ensure reliability and validity of the measures is the use of established measures or instruments (Babbie, 2009:1590). For data collection purposes, WtP questionnaires that were used during previous studies globally were adapted for use in this study. Furthermore, prior to administration, the WtP questionnaire (see Annexures C and D for the questionnaire) was piloted on 11 employees of the RTMC to verify whether there were any items in the questionnaire that were ambiguous, to address this before the actual administration of the questionnaire. The pilot study was conducted from 1 to 15 October 2017 for the first questionnaire and 2 to 10 May 2017 for the follow-up questionnaire. Internal consistency (Cronbach alpha) measurement of reliability did not apply in this study as very specific risk and scenario-based methods were used and no constructs measured on Likert-type response scales were included in the questionnaires.

## 1.5 DEFINITION OF TERMS

In order to ensure that critical terms used in this study are understood in context, it is necessary to provide an explanation of what they mean in the context of this study. The definitions of these terms are provided in sub-sections 1.5.1–1.5.12.

### 1.5.1 Road traffic crash

A *road traffic crash* is an event that produces injury and/or property damage. It involves a vehicle and occurs on a public road or while the vehicle is still in motion after running off the road (Bhalla et al., 2009:239; BITRE, 2009:1; Kudryavtsev, Nilssen, Lund, Grjibovski & Ytterstad, 2013:350; Lehohla, 2009:2; Risbey et al., 2010:1). Road traffic crashes are divided into four severity categories, namely fatal crash, major or serious crash, slight or minor crash and property damage only crash.

- A *fatal crash* is classified as any crash in which at least one person is killed (Bhalla et al., 2009:239; BITRE, 2009:1; Kudryavtsev et al., 2013:350; Lehohla, 2009:2; Risbey et al., 2010:1).
- Any crash in which at least one person is seriously injured, but not killed is classified as a *serious or major crash* (Cillié, 1975:16; De Haan, 1992:4-1; Goosen & Kolman, 1982:6; Glass & Hamilton, 1987:1; Morden, 1989:7).
- Any crash in which at least one person is slightly injured but not seriously hurt or killed is classified as a *slight or minor crash* (Cillié, 1975:16; De Haan, 1992:4-1; Goosen & Kolman, 1982:6; Glass & Hamilton, 1987:1; Morden, 1989:7). Glass and Hamilton (1987:2) add that medical attention may be required but this can usually be administered on site or in a doctor’s surgery.

- *Property damage only crash* is one where no injuries are suffered by anybody (Verburgh et al., 1985:10). As a result, no medical treatment is required (Glass & Hamilton, 1987:2). Furthermore, only damages to the vehicle(s) involved occur (De Haan, 1992:4-1). The same definition of *property damage only crash* was adopted for the purpose of this study.

Therefore, for the purpose of this research, a *slight or minor crash* was regarded as one in which at least one person is slightly injured, and the injured may require medical attention either at the scene of the crash or in a doctor's surgery.

Research by Kudryavtsev et al. (2013:350) defined road *traffic injury* as a bodily injury resulting from a crash and leading to at least 24 hours of hospitalisation, or requiring out-patient treatment. These injuries are also divided into three severity levels, namely fatal injury, serious injury and slight or minor injury (Kudryavtsev et al. (2013:350). Various definitions are reported in literature.

In essence, a *fatal injury* (*road fatality*) is defined as a death resulting from a road crash occurring on a public road, with unintentional death occurring within 30 days from injuries sustained in the crash (Bhalla et al., 2009:240; BITRE, 2009:2; Kudryavtsev et al., 2013:350). De Haan (1992:4-1) and Goosen and Kolman (1982:7) define a *fatal injury* as one which causes the death of one or more of the persons involved as a direct result of the crash, either immediately or subsequently up to a period of three months after the crash. A *road traffic crash fatality* is therefore a death resulting from injuries sustained in a road traffic crash, including those of a pedestrian, pedal cyclist, motorcycle rider, occupants of three-wheeled motor vehicle, occupant of pick-up truck or van, an occupant of a heavy transport vehicle, bus occupant and individuals injured in other land traffic crashes (such as animal riders, occupants of a railway train) (Lehohla, 2009:2). According to Risbey et al. (2010:1), a *road fatality* is a death resulting from a crash on a public road where unintentional death occurs within 30 days from injury sustained in the crash. For the purpose of this study, *road traffic crash fatality* was defined as an unintentional death that occurs within 30 days resulting from injuries sustained in a road traffic crash involving such victim as a pedestrian, cyclist, motorcycle rider as well as driver or passenger(s) of a motor vehicle.

A *serious injury* is one for which the person involved is either hospitalised or confined to bed, or any one of the following injuries whether or not the person is hospitalised: "fractures, crushings, concussion, internal injury, severe cuts and lacerations, and severe general shock necessitating medical treatment" (Cillié, 1975:16; De Haan, 1992:4-1; Goosen & Kolman, 1982:7).

A *slight injury* is "any injury of a minor nature, such as cuts, bruises, sprains and slight shock" (Cillié, 1975:16; De Haan, 1992:4-1; Goosen & Kolman, 1982:7) and this definition was used in the current study as well.

### 1.5.2 Human costs

Human value reflecting "pain, grief, and suffering" is referred to as human costs (Anh, Dao & Anh, 2005:1929). Wren and Barrell (2010:15) define *human costs* as the costs associated with the loss of life, life expectancy, quality of life, and physical and mental suffering resulting from an injury. Due to the lack of data for use in estimating the pain, grief and suffering value, it is widely recommended to consider the figures accepted by the Asian Development Bank (ADB) that *human cost* is calculated as:

- 28% of total costs for a *fatal crash*, and
- 50% of total costs for an *injury crash* (Rezaei, Arab, Matin & Sari, 2014:59).

Wren and Barrell's (2010) definition of *human costs* was adopted for the purposes of the current study.

### 1.5.3 Human capital approach (HCA)

The generic HCA estimates the expected value to society of forgone (or lost) output on an *ex post* basis, and 'output' in this context refers to the forgone economic contribution to society from both workplace and household participation, from the age at which premature death occurs to the end of the expected natural life (BITRE, 2009:21). The overseas Road Note 10 (Transport Research Laboratory [TRL], 1995:2–3; 1997:17) defines *human capital or the gross output approach* as a methodology that uses average wage rates (gross of tax) to determine lost output both for the year in which death occurred and for future years and costs in future years that the casualty might have lived to be discounted back to give present values. According to Rizzi and Des Dios Ortúzar (2006b:471) as well as Perovic and Tsolakis (2008:804), the HCA "rests on accounting principles: the benefit of avoiding a premature death is given by the present value of the income flow the economy could lose in that case". This is the definition that was applied in the current study.

### 1.5.4 Lost output

'Lost output' or 'production loss' refers to the loss of the productive capacity of those affected by a road crash suffered by the national economy (Anh, Dao & Anh, 2005:1928; Verburgh et al., 1985:27). Therefore, lost output refers to the contribution that crash victims can no longer make due to injury or death (Chin, 2003:519). In the case of an injured victim, the economic loss is measured in terms of the loss in productivity throughout the period of incapacity (Chin, 2003:519). This is estimated by tracing records of the duration that the victims are hospitalised or given medical leave of absence from work (Chin, 2003:519). On the other hand, for each fatality resulting from the crash, there will be a loss of future production of the individual in the economy and the age of the casualty at the point of death is considered (Chin, 2003:520). This cost component entails loss of production and income resulting from the temporary or permanent disability of the injured, and the complete loss of production of fatalities (Institute for Road Safety Research in the Netherlands [SWOV], 20122–3; Wijnen, 2013:3). Schutte (2000:4-3 to 4-4) identifies three categories of *loss of output,* namely loss of output due to:

- fatalities (premature death), which is defined as the output that would have been produced by those people killed in a road crash over the remainder of their economic lives (Schutte, 2000:4-3);
- serious injuries resulting from the fact that victims are unable to produce at their normal rate, either temporarily or permanently, depending on the nature of the injuries; and
- slight injuries resulting from the fact that victims will take sick leave, and because the economy will consequently suffer a corresponding loss in output.

For the purpose of this study, 'lost output' or 'production loss' was defined as loss of the productive capacity of those affected by a road crash suffered by the national economy due to:

- fatalities (premature death), defined as the output that would have been produced over the remainder of their economic lives by those people killed in a road crash (Schutte, 2000:4-3);
- serious injuries resulting from the fact that victims are unable to produce at their normal rate, either temporarily or permanently, depending on the nature of the injuries; and
- slight injuries resulting from the fact that victims will take sick leave and because the economy will consequently suffer a corresponding loss in output.

### 1.5.5 Property damage costs

'Property damage costs' refers to damage to vehicles, freights, roads and fixed roadside objects (Verburgh et al., 1985:19; Glass & Hamilton, 1987:18). However, the majority of property damage concerns damage to vehicles, and the estimation of these costs is based on insurance data, such as damage claims paid, and estimates of the damage not claimed and the damage not compensated (SWOV, 2012:2–3; Wijnen, 2013:3). According to Wijnen, Schroten and 't Hoen (2016:26), *property damage costs* mainly comprises vehicle damage costs. However, Anh, Dao and Anh (2005:1927) assert that *property damage costs* include repairs and replacement of infrastructure components and vehicle parts, which also include generated charges (such as storage charges by panelbeaters) during the period the damaged vehicles are out of service. According to Verburgh et al. (1985:19) and Glass and Hamilton (1987:18), *property or material damage* caused by road crashes comprises damage to:

- vehicles;
- objects inside vehicles and the personal effects of casualties and occupants (such as vehicle cargoes, clothing, spectacles and wristwatches); and
- objects outside vehicles, whether fixed or movable (such as roadside objects or fixed property).

However, for the purpose of this study, the definition of Wijnen et al. (2016:26) was adopted, namely that *property damage costs* comprise vehicle damage costs.

### 1.5.6 Medical costs

According to Ahn et al. (2005:1927), *medical costs* include cost of crash scene care, transport, in-hospital stay, out-patient treatment, drugs and prosthetics. *Medical costs* mainly comprise four cost types, namely:

- the cost of treatment by professional medical and para-medical practitioners, such as doctors, dentists, surgeons, anaesthetists, osteopaths and nurses;
- the fees charged by hospitals and nursing homes (both for in-patients and out-patients) for hospitalisation and ancillary services;
- the cost of supplies and medication purchased by crash victims (and not included elsewhere) whether on prescription or not; and
- ambulance costs (Verburgh et al., 1985:23).

The above are therefore costs resulting from the treatment of casualties, e.g. costs of hospital stay, rehabilitation, medicines and adaptations for the handicapped (SWOV, 2012:3; Wijnen, 2013:3). The same definition was adopted for the purpose of this study.

### 1.5.7 Administrative costs

In the context of road crashes, the term ‘administrative costs’ refers to traffic police service cost, emergency response service cost, cost of insurance and court administration costs (Ahn et al., 2005:1928; Verburgh et al., 1985:27). Verburgh et al. (1985:27) and Glass and Hamilton (1987:28) define ‘administrative costs’ as consisting of costs of insurance and costs of the police, which they divide into two categories: on-scene crash investigation, and investigation undertaken by the uniformed investigation branch (UIB). Therefore, for the purpose of the current research, in line with Ahn et al. (2005), ‘administrative costs’ was taken to refer to insurance costs, police service costs, emergency response service costs and court administration costs.

### 1.5.8 Congestion costs

Crashes cause delays, which result in non-recurrent congestion affecting other road users, such as:

- travel delays due to time lost queuing in traffic or from reduced travel speeds;
- increased fuel use; and
- increased health consequences from additional local air pollution due to gas emissions (Risbey et al., 2010:10).

Congestion costs entail the value of travel delay, added fuel usage, greenhouse gas and criteria pollutants (see Risbey et al., 2010; Blincoe, Miller, Zaloshnja & Lawrence, 2015) that result from congestion, which in turn results from motor vehicle crashes (Blincoe, et al, 2015:287). Therefore, travel delay costs comprise the estimated value of the time lost due to queuing in traffic or from reduced travel speeds due to a road crash (Blincoe et al, 2015:287). Research data on total traffic congestion costs, the share of lost time due to crashes used to estimate these costs, and the time lost due to traffic congestion as a result of crashes are based on data about congestion intensity (SWOV, 2012:2–3; Wijnen, 2013:3). Therefore, for the purpose of this study, congestion costs due to travel delays, added fuel usage due to queuing in traffic or from reduced travel speeds, greenhouse gas emissions and the associated cost estimates were based on data about congestion intensity.

### 1.5.9 Willingness to pay approach (WtPA)

The WtPA is widely used in cost–benefit analyses in the fields of environmental economics, health economics and increasingly in transport economics and it is based on the utilitarian principle that underlies welfare economic theory (see Irshad, 2016) in which benefits are deemed to be based on consumer preferences (Sakashita, Jan & Ivers, 2012:n.p.). The WtPA is defined as a method that values society's willingness to pay for avoiding death, injury and property damage as a result of road crashes (Labuschagne, 2016:9; Perovic & Tsolakis, 2008:806). This definition is premised on the assumption that, if an individual provides rational responses to the risks that he or she and his or her family perceives, their response should reveal their willingness to reduce injury and/or death resulting in a value that reflects:

- the family's monetary costs of illness, injury and death;
- the effects on quality of life as a result of injury (pain and suffering of self and loved ones);

- the sense of security derived from being safe and healthy; and
- people's aversion to gambling involuntarily with their lives and livelihoods.

The overseas Road Note 10 (TRL, 1995:2–3; 1997:17) defines the WtPA in terms of valuing the costs of crashes as a methodology that is based on the fundamental premise that decisions made in the public sector concerning the allocation of scarce resources should reflect the preferences and wishes of those individual citizens who will be affected by the decisions.

For the purpose of this study, the definition of Perovic and Tsolakis (2008) and Labuschagne (2016) was adopted and used.

It needs to be noted that there are two methods of the WtPA that Abdallah et al. (2016:12) and Le et al. (2011:3) recommend in order to ensure a balance between using a reliable and up-to-date method, namely the contingent valuation method (CVM) and the stated preference method (SPM). These two methods are defined in the sub-sections below.

#### 1.5.10 Contingent valuation method (CVM)

The CVM is a survey-based approach for eliciting consumers' monetary valuations (willingness to pay) for a policy measure (Sakashita et al., 2012:n.p.). The CVM involves eliciting people's WtP for welfare improvements or a hypothetical reduction in the risk of dying during a given time period (Mahmud, 2005:2; Quah & Toh, 2012:15). Bergmann (2007:272) defines the CVM as a survey method in which individuals are presented with information about specific environmental change, and their perception, attitudes and preferences regarding these changes are elicited. In order to measure the effects of the suggested changes on people's welfare, respondents are typically asked for either their willingness to pay or their willingness to accept compensation for the gains or losses involved (Bergmann, 2007:272). This valuation method expresses in monetary terms the change in economic welfare arising from a change in the quality or quantity of services, which in this case is road traffic safety management of a country (Niroomand & Jenkins, 2016:3). Therefore, in contingent valuation surveys, individuals are asked what they are willing to pay for a defined health benefit or for a reduction in risk (Abelson, 2008:7). The current study adopted the latter definition.

#### 1.5.11 Stated preference method (SPM)

In an SPM, respondents are asked to choose between alternative combinations and attributes and their levels; therefore, the method is centred on actual behaviour of individuals, and it is thought to provide the valuation of intangibles with high precision

(Niroomand & Jenkins, 2016:3). A stated preference survey requires respondents to choose among different hypothetical alternatives, characterised by a set of relevant attributes. In the current study, the three attributes were the number of fatalities, which serves as a proxy for risk, travel time, and user-pay cost for using the routes considered (Rizzi & Ortúzar, 2006a:71). Therefore, SPMs derive estimates of willingness to pay values from individual responses to survey questions (Abelson, 2008:7). The SPM is considered the most appropriate method to value road safety because of its robustness and its ability to cope with assessment on improvement (Yusoff et al., 2013:7). This study therefore adopted the definition used in these studies.

### 1.5.12 Value of a statistical life

The economic approach to valuing risks to life focuses on risk–money trade-offs for very small risks of death, or the value of statistical life (León & Miguel, 2013:2; Rheinberger, 2009:2; Viscusi, 2005:1). Rheinberger, Schläpfer and Lobsiger (2017:2) and Mahmud (2005:2) assert that the marginal rate of substitution between wealth and mortality risk – commonly referred to as "the value of statistical life" (see Viscusi, 2005:1) – is a major determinant of transport policies, amongst others. The value of a statistical life in a road traffic context is estimated by examining the relationship between an individual's willingness to pay for a marginal reduction of the risk of being killed in a road traffic crash and the reduction or change of that fatality risk (Yusoff et al., 2013:7). The value of statistical life is an estimate of the financial value society places on reducing the average number of deaths by 1 (Office of Best Practice Regulation [OBPR], 2014:1). According to Hensher et al. (2009:692), the value of a statistical life, more appropriately referred to as "the value of risk reductions" (see Hensher et al., 2009:692), is based on subjective preferences. It is defined as the amount of money that individuals are willing to pay for reducing the risk of their premature death or of injury, while performing a certain risky activity, such as travelling on the road (Andersson, 2007:855). This is also a definition of the marginal rate of substitution between wealth and mortality risk (Andersson, 2007:855). Similarly, according to Andersson and Treich (2011:2), 'the value of a statistical life' refers to the monetary value of a mortality risk reduction that would prevent one statistical death and therefore should not be interpreted as how much individuals are willing to pay to save an identified life. Rafiq (2011:1) and Charalampos (2016:5) also report that economists term a trade-off between money and fatality risks 'the value of a statistical life'. Svensson (2009:2–3), Banzhaf (2014:213) and Shanmugam (2013:1) define 'the value of a statistical life' as the willingness to pay for a small risk reduction for each individual in society, which overall is expected to prevent one premature death. It can therefore be concluded that the standard measure of the WtP value is the trade-off rate between money and fatal injury risks, or what is known as ‘the value of a statistical life’, and the value of a statistical life describes the rate at which individuals are willing to forgo money for an infinitesimal reduction in risk (Kniesner, Viscusi & Ziliak, 2014:188; Leiter & Pruckner, 2006:2). The current study adopted the definition by Andersson and Treich (2011:2).

### 1.6 SIGNIFICANCE OF THE STUDY

Road safety ranks low in national health and development priorities even though the large public health burden of traffic crashes has been known since the mid-1990s when the results from the first GBD Study were published (Bhalla, 2013:48). However, safety programmes require large and sustained investments in a wide range of areas, including strengthening national institutions, highway infrastructure, vehicle design, trauma care, law enforcement and education for safe road use. Motivation for resource allocations to ensure that these investments achieve their intended objectives needs to be supported by well-researched economic arguments to assist policymakers and planners who manage the allocation of financial resources. Estimates of the economic impact of road crashes can provide guidance in such decision-making (Bhalla, 2013:8; Bliss & Breen, 2009:11; Wijnen & Stipdonk, 2016:97).

Despite a strong move globally towards the use of the CVM in estimating road crash costs and the critical role road crash cost estimates play in policy dialogues, South Africa has been using the HCA to estimate the cost of road traffic crashes. Given global developments in terms of approaches used in estimating crash costs particularly in favour of the WtPA, estimates that were calculated using the HCA may be outdated and not comparable globally, particularly due to methodological flaws. The current study therefore developed a hybrid framework for assessing the costs of road traffic crashes. Various benefits flow from this study, amongst others:

- SA policy debates and road safety programmes affect analysis and resource allocation decisions that are based on up-to-date crash cost estimates;
- SA road crash cost estimates are comparable to those of countries that have proved to be global leaders in road safety performance since estimates that emanate from the current study were calculated using methods that those countries use;
- the ratio of road crash cost estimates is determined using the GDP; and
- recommendations are provided on how future crash cost valuation methods could be improved.

Details on the significance of the study are further provided as part of the contribution of the study (see section 6.5).

## 1.7 ETHICAL CLEARANCE

Research should be based on voluntary participation, no harm to the participants, anonymity and confidentiality, mutual trust, acceptance and informed consent, cooperation, promises and well-accepted conventions and expectations between all parties involved in a research project (Babbie, 2011:66–76; De Vos, Strydom, Fouché & Delport, 2014:115–122; Neuman, 2014:71–79; Van Zyl, 2014:85–89). Prior to execution of this study, approval was sought from the University of South Africa (Unisa) Ethics Committee and the National Department of Transport (NDoT), RAF, RSR, RTMC, C-BRTA, South African National Roads Agency Limited (SANRAL) and RTIA. Ethics committees are intended to review research proposals according to strict guidelines and procedures before researchers are allowed to commence with data collection (De Vos et al., 2014:126–127; Terre Blanche, Durrheim & Painter, 2014:61). Approval by the Unisa Ethics Committee was subsequently granted on 25 August 2017 (see Appendix G for Ethics Clearance Certificate). The study therefore adhered to Unisa research ethics guidelines.

Furthermore, in line with Cooper and Schindler (2014:32), the WtP questionnaire (see questionnaire in Annexure C) was accompanied by an information sheet, which provided respondents with all the necessary background information about the study and their rights, thus serving the same purpose as traditional debriefing sessions and adhering to the necessary consent needed in terms of:

- explanation of any deception, if any;
- description of the purpose of the study; and
- sharing of results after the study had been completed.

## 1.8 OUTLINE OF CHAPTERS

This research report consists of the following six chapters, and the layout thereof is discussed below.

***Chapter 1: Introduction to the study***. This chapter introduced the topic ‘cost of road crashes’, followed by an analysis of the problem leading to the problem statement, the main aim of the study, delineation of the field of study, definition of concepts/terms used in the research report. It also provided the contextual setting of the study in terms of the global trends regarding the assessment of the cost of road crashes. Furthermore, this chapter included the research objectives, ethical considerations, an explanation of the importance as well as the limitations of the study.

***Chapter 2: Road traffic crash cost assessment: An international perspective.*** In Chapter 2, a detailed review of literature on various theories underpinning the importance of crash cost estimates in policymaking and road safety programme prioritisation and funding, amongst others is provided. The chapter further provides a review of literature dealing with international best practices in the assessment of the cost of road crashes.

***Chapter 3: A South African perspective on road crash statistics and road traffic crash assessment.*** This chapter is presented in the form of a literature review on the SA state of road safety and economics of road traffic crashes. In this chapter, the researcher discusses trends in the number of road crashes, fatal crashes, fatalities, injuries and vehicle types comparing road crash statistics of the last five years from 2013 to 2017. The chapter also entails road crash cost assessment approaches, cost components and estimates of previous studies conducted in South Africa.

***Chapter 4: Selected approaches and methods to assess the costs of road crashes in South Africa.*** Based on a literature review on international best practices in terms of the assessment of road crash costs, this chapter provides a detailed comparison of methods used in previous cost assessment studies in South Africa with methodologies currently used globally, particularly by countries that have good practices in road safety performance and road traffic cost assessment. This comparison culminates in recommendations for areas that need enhancement in the road crash cost valuation approaches previously used in South Africa. The chapter concludes by outlining the approaches used in this study to assess the 2017 cost of crashes as well as the research methodology followed in the research.

***Chapter 5: Road traffic crash cost assessment in the South African context***. This chapter starts by presenting and discussing road crash cost estimates computed by adjusting the 2016 cost estimates from the Cost of Crashes in South Africa report that was commissioned by the RTMC by the 5.3% inflation rate of the year 2017. Secondly, the chapter provides a detailed process of calculating 2017 cost estimates using two methods of the WtPA, namely the CVM and the SPM. It also presents cost estimates calculated using these two methods.

***Chapter 6: Conclusions and recommendations for road traffic crash cost assessment in South Africa***. Finally, the conclusions and recommendations in line with the primary and secondary objectives of the study are outlined. In terms of the primary objective, the hybrid framework is presented in this chapter. Chapter 6 will also provide recommendations for areas for further research and ways to improve future crash cost assessment studies in South Africa.

# CHAPTER 2:
# ROAD TRAFFIC CRASH COST ASSESSMENT: AN INTERNATIONAL PERSPECTIVE

## 2.1 INTRODUCTION

The increasing need for sustainable transportation systems, driven by demand for both personal and freight mobility, requires the efficient allocation of resources, and this needs the proper quantification of the associated costs and benefits (Bahamonde-Birke, Kunert & Link, 2015:488). A comprehensive evaluation of road investment projects requires an assessment of social damages caused by road crashes (Koyama & Takeuchi, 2004:119). In particular, the primary purpose of studies to estimate the cost of road crashes is to illustrate the need for increased attention to road safety (Bhalla, 2013:10). The valuation of road crashes – which apart from such externalities as congestion, environmental and noise pollution represents one of the most negative impacts of road transport – is a challenging task (Bahamonde-Birke et al., 2015:488).

As envisaged by the first secondary research objective of this study (see sub-section 1.3.2), one of the critical cornerstones of any effort to improve road crash cost assessment is to start by reviewing literature on international best practices in the assessment of the cost of road traffic crashes. This will ensure comparability of approaches used to estimate the costs with state-of-the-art road crash cost assessment practices globally as well as to provide a robust and sound theoretical and methodological basis for cost assessment. Furthermore, the fact that South Africa is a signatory to such global road safety initiatives as the United Nations Decade of Action for Road Safety 2011–2020 (see World Health Organization [WHO], 2011), makes a strong case for the need to update cost estimates using approaches employed globally to ensure comparability of cost estimates across countries.

Considering the fact that before the most recent study conducted in 2016 (see Labuschagne, 2016) using 2015 data (see Labuschagne, 2016), and that the last road crash cost assessment study in South Africa was conducted in 2004 using 2002 data (see De Beer & Van Niekerk, 2004) has numerous implications for the reliability and currency of the estimates that were used before the 2016 study:

- The road crash cost estimates are outdated since there have been many developments around approaches used in the assessment of such estimates and the economy.

- The estimates are not comparable to those of other countries since those countries have calculated very recent estimates using updated methods, for example the United States of America and Australia produced their road crash costing reports in 2015 and 2010 (see Blincoe et al, 2015 & BITRE, 2009). In these studies, the two countries did not just update their estimates, but they also updated their approaches as well (see Blincoe et al, 2015 & BITRE, 2009).
- Outdated estimates may result in ill-informed policy decisions leading to under-resourcing of road safety initiatives (Labuschagne, 2016).

What is even more concerning is that even the 2016 study used the same approach used in prior studies, namely the HCA (see Labuschagne, 2016). This is despite the fact that there is currently a methodological shift in favour of the WtPA in the calculation of the cost of road crashes where some countries consider the approach as the only evaluation method or inclusion of this method in HCA crash cost valuation studies as a complementary evaluation tool (Bahamonde-Birke et al., 2015:503). This shift came about because the WtPA overcomes some of the important shortcomings of the HCA (Bahamonde-Birke et al., 2015:503).

In order to contribute towards the achievement of the first objective, this chapter provides a detailed review of literature on road crash cost assessment practices of seven countries (Australia, Belgium, Egypt, Netherlands, United Kingdom, United States of America and Singapore). This literature review culminates in the identification of the relationship between the HCA and the WtPA; thus, informing the development of a hybrid framework for assessing the cost of road traffic crashes in South Africa. By doing so, the review provides an international perspective towards achieving the fourth secondary objective (see 1.3.2) by structuring the cost components of and the relationship between the HCA and the WtPA.

Figure 2.1 depicts the structure and flow of Chapter 2, which addresses road traffic crash assessment from an international perspective:

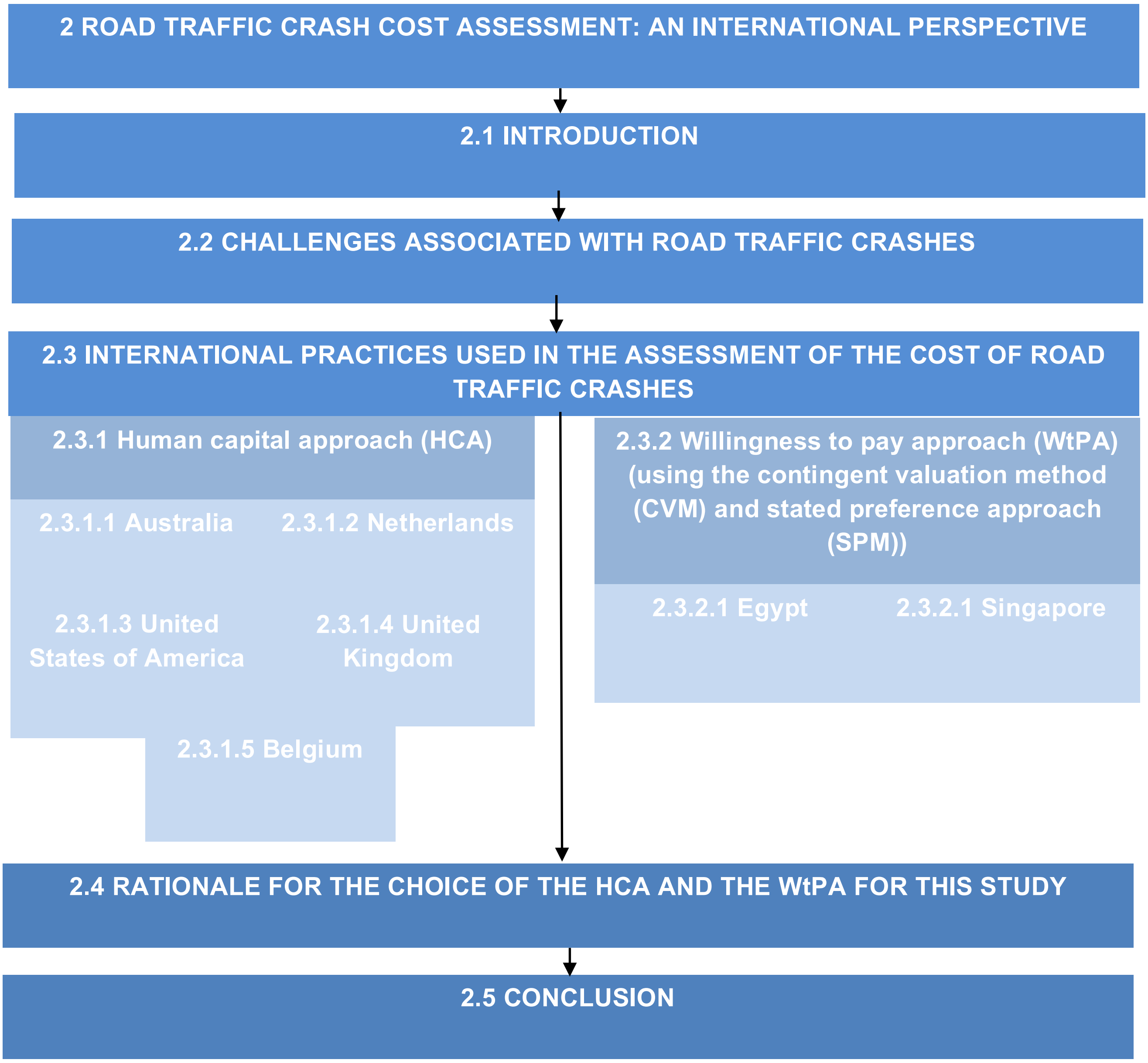


**Figure 2.1: Structure of Chapter 2**

As Figure 2.1 shows, Chapter 2 starts with an introduction that provides an overview of the importance of reviewing literature on international practice with regard to road traffic crash valuation. The introduction further demonstrates how the literature review painted a picture from an international perspective that contributed towards the achievement of the first and second secondary objectives (see 1.3.2. It also briefly presents the benefit of regularly updating the road traffic cost estimates in terms of both the approaches used as well as the values themselves. The introduction is followed by a discussion of the challenge road traffic crashes pose to any country, particularly from health, social and economic perspectives (section 2.2). The chapter then presents the components the seven selected countries consider in their assessment of road traffic crash costs (section 2.3). It is worth noting that five (Australia, Belgium, the Netherlands, the United Kingdom and the United States of America) of the countries are discussed under the HCA (see 2.3.1) and the other two (Egypt and Singapore) are discussed under the WtPA (see 2.3.2). It also demonstrates how each country applies the cost components to conduct valuation of its road traffic crash costs by presenting a detailed breakdown of how each country considers these components (section 2.3). Prior to the conclusion of the chapter, the rationale behind the choice of the two approaches, namely the HCA and the WtPA, is provided (section 2.4). The chapter then ends with a conclusion summarising the key findings from the international literature review and also demonstrating how the review contributed towards the achievement of the objectives of this study, particularly the first and fourth secondary objectives (see 1.3.2).

The next section presents a discussion of the approaches used in the assessment of the costs of road traffic crashes.

## 2.2 APPROACHES FOR ASSESSING THE COSTS OF ROAD TRAFFIC CRASHES

As indicated in Chapter 1, there are six different approaches that are used in road crash cost assessment (Ahadi & Razi-Ardakani, 2015:164; Alrukaibi et al., 2015:46; TRL, 1995:2–3; 1997:17) (see section 1.2). These six approaches are briefly explained next.

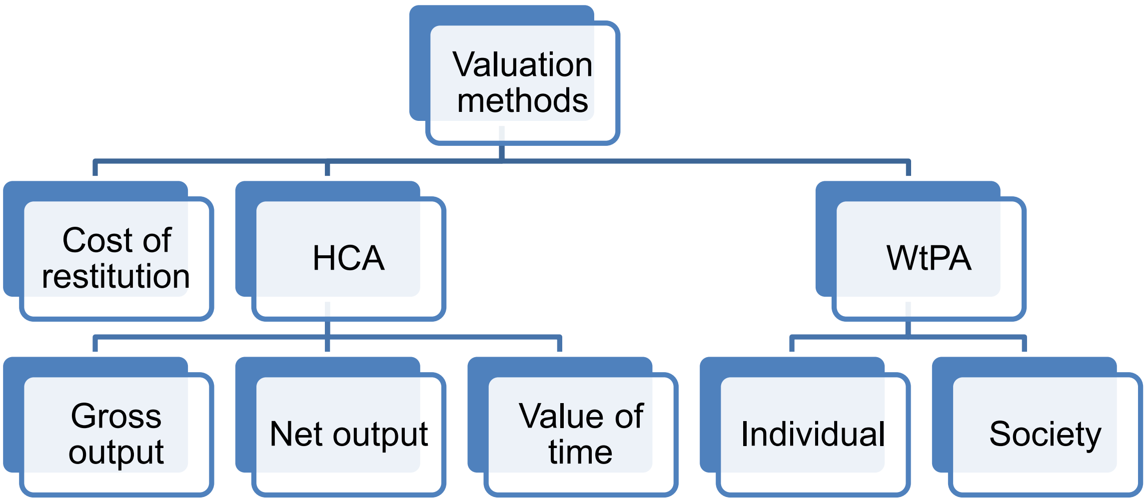


**Figure 2.2: Approaches for assessing the costs of road traffic injury**

*Source: Janota, Rástočný and Zahradní (2008:46)*

- ***The gross output (or human capital) approach***: In this approach, average wage rates are used (gross of tax) to determine lost output both for the year in which death occurred and then for future years. Costs in future years that the casualty might have lived have to be discounted back to give present values.

- ***The net output approach***: The difference between the HCA and the net output approach is that in the net output approach, the discounted value of the victim's future consumption is subtracted from the gross output figure.
- ***The life-insurance approach***: In this method, the cost of a road crash or the value of crash prevention is directly related to the sums for which 'typical' individuals are willing (or even able) to insure their own lives (or limbs).
- ***The court award approach***: In this approach, the sums awarded by the courts to the surviving dependants of those killed or injured are regarded as an indication of the cost that society associates with the road crash or the value that it would have placed on its prevention.
- ***The implicit public sector valuation approach***: This method attempts to determine the costs and values that are implicitly placed on crash prevention in safety legislation or in public sector decisions taken either in favour of or against investment programmes that affect safety.
- ***The value of risk change or WtPA***: This approach is based on the fundamental premise that decisions made in the public sector concerning the allocation of scarce resources should reflect the preferences and wishes of those individual citizens who will be affected by the decisions.

The cost of the restitution approach mentioned in Figure 2.2 entails all the other approaches (except the HCA and the WtPA) that are based on assessing a monetary value for restitution, namely the life insurance approach, court award approach, implicit public sector valuation approach, and net output approach (Janota et al., 2008:46). Despite the six approaches outlined above, there are two commonly used approaches in the assessment of road crash costs, namely the WtPA and the HCA or gross output approach (iRAP, n.d.; Schutte, 2000:2-4).

Given the plethora of approaches used by different countries for the estimation of the cost of road traffic crashes, it was necessary to review literature to establish which valuation practices are used by which countries. The literature review ensured the achievement of the first and second secondary objectives (see 1.3.2). The review culminated in recommendations on practices that could either be adapted or replicated for the purpose of the current and future studies in the valuation of the cost of road crashes for South Africa (see Chapter 4 for details).

Sub-sections 2.3.1 and 2.3.2 provide a detailed review of literature on the approaches used by the seven countries selected for the study in the estimation road crash costs.

## 2.3 INTERNATIONAL PRACTICES USED IN THE ASSESSMENT OF THE COST OF ROAD TRAFFIC CRASHES

Road crash cost assessment studies have been conducted in many countries. This section presents a discussion of the approaches used in the valuation of these costs from an international perspective. In particular, the discussion focuses on road crash cost assessment studies conducted in seven countries, namely Australia, Belgium, the Netherlands, United States of America, United Kingdom, Singapore and Egypt; providing an international perspective. The literature review particularly provides an overview of road crash cost assessment practices with a special focus on:

- cost components considered in road crash cost assessment in each of the seven countries; and
- presentation of cost assessment tables showing how the different cost components are used to obtain total costs of road traffic crash costs as applied in each of the seven countries.

It is of paramount importance to point out from the onset that globally, countries use similar categories of crash costs in the estimation of overall crash costs. Table 2.1 summarises these broad categories. The table reflects three categories of road crash costs (namely human costs, vehicle costs and general costs), two types of cost components (direct and indirect costs) and four costing unit (crash severity level, injury severity level, type of injury and crash type).

**Table 2.1: Categories of road crash costs**

| Category | Type of cost | | Component | Costing unit |
|---|---|---|---|---|
| Human costs | Direct | Medical | Hospital in-patient | |
| | | | Hospital out-patient | |
| | | | Transport/ambulance | |
| | | | Medical and allied health care | |
| | | | Drugs and laboratory tests | |
| | | | Counselling | Crash severity level, injury severity level, type of injury, crash type |
| | | | Long-term care | |
| | | Non-medical | Criminal prosecution | |
| | | | Correctional services (for traffic offenders that are found guilty) | |
| | | | Legal services | |
| | | | Coroner | |
| | Indirect | Tangible | Loss of productivity (earnings and time) | |
| | | Intangible | Health-related quality of life | |

| Category | Type of cost | Component | Costing unit |
|---|---|---|---|
| Vehicle costs | Direct | Repairs | |
| | | Towing | |
| General costs | Direct | Non-vehicle property damage | |
| | | Police and emergency services | |
| | | Vehicle insurance administration | |
| | Indirect | Travel delays | |

*Source: Hendrie and Miller (2012:7)*

Noteworthy is the fact that, with the exception of travel delays for the latter, both vehicle repair and general cost categories consist of direct costs, which include:

- vehicle repairs and towing costs;
- non-vehicle property damage;
- police and emergency services; and
- vehicle insurance administration.

Further, research by De Leon et al. (2005:3185) classifies the crash components into three categories, namely victim-related costs, property damage and administration (police investigation, insurance and legal costs) costs. Each of these costs categories consists of cost components. The details of these are indicated in Figure 2.2 below.

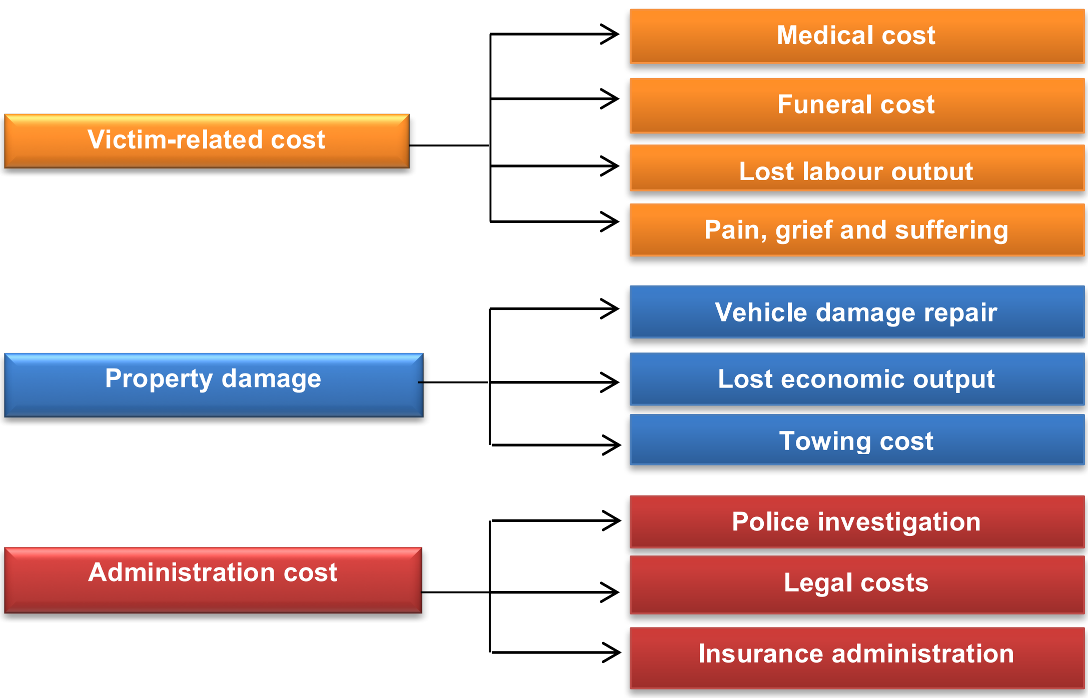


**Figure 2.3: Classification of crash cost components**

Crash cost components identified by Hendrie and Miller (2012:7) reflected in Table 2.1 and by De Leon et al. (2005:3185) reflected in Figure 2.2 are in keeping with the three types of cost of casualties identified by the Swedish National Road Consulting (SweRoad) (2001:13–14) as used in Sweden, namely the direct costs (these are property damage costs, hospital costs and administration costs), indirect costs (costs not directly paid by anyone, such as loss of production) or in the case where a risk value (that is an estimate of the cost of a risk calculated by multiplying probability by impact) is used, the loss of net production (gross production minus consumption) and risk value, which reflects the pain and suffering of the victim as well as the grief and sorrow of his or her family and/or friends. However, the Victoria Transport Policy Institute (2018:5.3–14) classifies the major crash cost categories in Table 2.2 as market and non-market costs that need to be considered in the process of estimating the cost of a crash. As it is evident from Table 2.2, market costs and non-market costs consist of five and four crash costs respectively.

**Table 2.2: Crash costs classification: Market and non-market cost components**

| **Market** | **Non-market** |
|---|---|
| • Property damages to vehicles and other objects<br>• Lost income<br>• Emergency response services<br>• Medical treatment costs<br>• Crash prevention and protection expenditures | • Crash victim's pain and suffering<br>• Crash victim's lost quality of life<br>• Uncompensated grief and lost companionship to crash victims' family and friends<br>• Reduced non-motorised travel due to crash danger |

*Victoria Transport Policy Institute (2018:5.3-3)*

Despite the observation that most countries use similar approaches in line with the categories in Table 2.1 for the assessment of the cost of road traffic crashes, there are differences in data sources, methods used to calculate human costs (in terms of both the approach itself and the discount rate) as well as cost components that the countries consider in the determination of their estimates. It is for this reason that a detailed analysis of each approach was necessary to inform the choice of practices that would help improve approaches used in the assessment of road crash costs in South Africa.

For this purpose, firstly five countries for which crash cost valuation studies were conducted using the HCA or the modified or hybrid HCA were selected, namely Australia, Belgium, the United States of America (USA), the Netherlands and the United Kingdom (UK). These countries were selected on the basis that they had a good road safety record at the time of this research as determined based on the number of fatalities per 100 000 inhabitants and per 100 000 vehicles, and/or good road crash cost assessment studies with available reports. Table 2.3 summarises the criteria that were used to select the five countries that were also amongst the seven that were considered in this study for a detailed review of practices for the assessment of road crash costs. The countries are arranged in alphabetical order.

**Table 2.3: Criteria used for the selection of countries**

| Country | Road fatalities per 100 000 inhabitants per year | Road fatalities per 100 000 motor vehicles | Total fatalities latest year (adjusted or estimated figures by WHO report) | Year | Selected | Selection criteria | |
|---|---|---|---|---|---|---|---|
| | | | | | | Safety record | Estimation practice and availability of literature |
| **World** | **18** | **93.3** | **1 240 000** | | **N/A** | **N/A** | **N/A** |
| Australia | 5.6 | 7.6 | 1 299 | 2012 | Yes | Yes | Yes |
| Austria | 5.3 | 7.2 | 558 | 2010 | No | Yes | No |
| Belgium | 7.2 | 8 | 796 | 2012 | Yes | Yes | Yes |
| Brazil | 22.5 | 67.7 | 43 869 | 2010 | No | No | No |
| Canada | 6 | 9.3 | 2 075 | 2011 | No | Yes | No |
| China | 20.5 | 133.3 | 275 983 | 2010 | No | No | No |
| Denmark | 3.0 | 5.7 | 167 | 2012 | No | Yes | No |
| Finland | 4.7 | 6.6 | 255 | 2012 | No | Yes | No |
| France | 4.9 | 8.5 | 3 250 | 2013 | No | Yes | No |
| Germany | 4.3 | 6.9 | 3 520 | 2013 | No | Yes | No |
| India | 19.5 | 207.5 | 238 562 | 2013 | No | No | No |
| Ireland | 4.2 | 8.1 | 195 | 2014 | No | Yes | No |
| Italy | 6.2 | 7.6 | 3 753 | 2012 | No | Yes | No |
| Japan | 4.8 | 7.3 | 6 090 | 2012 | No | Yes | No |
| Russia | 18.6 | 55.4 | 27 991 | 2012 | No | No | No |
| Netherlands | 3.9 | 6.9 | 650 | 2012 | Yes | Yes | Yes |
| South Africa | 31.9 | 156.4 | 14 993 | 2011 | N/A | N/A | N/A |
| Spain | 3.6 | 5.2 | 1 680 | 2013 | No | Yes | No |
| Sweden | 3 | 5.1 | 285 | 2012 | No | Yes | No |
| Switzerland | 3.4 | 4.7 | 269 | 2013 | No | Yes | No |
| United Kingdom | 3.5 | 6.2 | 2 175 | 2012 | Yes | Yes | Yes |
| United States | 11.6 | 13.6 | 36 166 | 2012 | Yes | Yes | Yes |

*Source: Adapted from WHO (2015)*

Table 2.3 shows that only countries with road fatalities per 100 000 inhabitants per year and road fatalities per 100 000 motor vehicles below the world averages, of 18 and 93.3 respectively, as well as both a good road safety performance record and road crash cost assessment practices documented in crash costing reports were selected. Gitelman, Vis, Weijermars and Hakkert (2014:139) assert:

> When monitoring the progress, road safety is usually assessed in terms of accidents, injuries or their social costs. However, simply counting accidents or injuries mostly does not offer enough insight into the underlying processes. Typically, accidents or injuries are only the tip of the iceberg, because they occur as the 'worst case' of unsafe operational conditions of the road traffic system.

Therefore, a good road safety performance record of a country is characterised by safe operational conditions of the road traffic system resulting in minimal to no crashes, injuries or their social costs. It is therefore critical to determine inputs into CBA to assist in investment decisions in or resource allocation to road safety projects and prioritising projects to address the unsafe operational conditions of the road traffic system. One of the most important inputs into CBA is the cost of road traffic crashes. In order for these cost estimates to be reliable and therefore able to serve the intended purpose, they need to be assessed using state-of-the-art approaches and methods. It is for this reason that countries that were showing exceptional road safety performance at the time of this research were selected for benchmarking their road traffic crash cost assessment practices so that these can either be replicated or adapted for use in South Africa (see Table 2.3). Road safety performance and/or availability of road crash assessment reports and good practice displayed in the reports were the selection criteria used in the selection of five of the seven countries (Australia, Belgium, the Netherlands, the United Kingdom and the United States of America) considered in the current literature review.

The second set of countries was selected because their road crash cost assessment studies used the WtPA, particularly the CVM and SPM of this approach. In particular, studies conducted in Egypt and Singapore were considered for this purpose.

Following is a review of practices in the estimation of the cost of road traffic crashes in these seven countries, namely Australia, Belgium, Egypt, the Netherlands, Singapore, the United Kingdom and the United States of America. As indicated in the preceding paragraphs, these countries have been chosen for either their good road safety performance record and/or excellence in the approaches used in the assessment of road traffic crash costs; particularly in the use of the HCA and the WtPA).

### 2.3.1 Human capital approach (HCA)

Of the seven countries selected for the purpose of this study, five used the HCA or a hybrid HCA to assess the cost of road crashes at the time of the current research. These five countries were Australia, Belgium, the Netherlands, the United Kingdom and the United States of America. Section 2.3.1 presents cost categories, cost components and the way the HCA was applied to assess the costs of crashes in each of these five countries.

#### *2.3.1.1 Australia*

Official estimates of the costs of road crashes in Australia are published approximately every 10 years by the agency called BITRE located within the federal government responsible for transport. The most recent estimate (that for 2006) was published in 2009 by BITRE (see Hendrie & Miller, 2012). The loss of life and quality of life provides a challenge to estimating the costs of road crashes because a vehicle can be replaced (at a market-determined price), but a human life cannot (Tooth, 2010:1). The approach used in measuring human costs for the 2006 estimates is a variant of the HCA, which BITRE calls the “hybrid HCA” (see BITRE, 2009:22), in which a notional value for the quality of life lost in the event of premature death was added to lost production and other costs (Hendrie & Miller, 2012:25–26). This approach estimates the value of productive output of people over their remaining lifetime (Tooth, 2010:1). However, the application of the HCA (including proposed hybrid alternatives like the one used by BITRE in the assessment of the 2006 crash cost) has largely excluded benefits of life (e.g. leisure) not associated with production and thus underestimated the value derived from life (Tooth, 2010:1).

Table 2.4 summarises the cost components used in Australia to estimate costs of road crashes using the hybrid HCA. As Table 2.4 shows, the cost components considered in the assessment of road traffic crashes in Australia fall under direct and indirect costs. Direct costs are further divided into four sub-categories, namely direct medical human costs, direct non-medical human costs, direct vehicle costs and direct general costs. Indirect costs are divided into three sub-categories, namely indirect tangible human costs, indirect intangible human costs and indirect general costs.

**Table 2.4: Cost categories in the Australian crash cost estimates**

| | |
|---|---|
| **Direct medical human costs** | |
| Medical | Includes ambulance, medical, hospital in-patient and paramedical costs |
| **Direct non-medical human costs** | |
| Disability-related costs | Costs of providing care for people with a disability, including careers, specialist accommodation, therapy and specialist services, day programmes, aids and equipment, and home modifications |
| Recruitment and retraining costs | Recruitment costs to replace casualties with profound limitations and the costs of re-training people with severe limitations to take on alternate duties |
| Workplace costs | Costs borne by employers, including output foregone and costs associated with hiring temporary employees |
| Insurance administration | Administrative costs associated with processing insurance claims resulting from motor vehicle crashes |
| Legal costs | Legal fees and court cases associated with civil litigation resulting from traffic crashes |
| **Indirect tangible human costs** | |
| Market productivity | Present discounted value of the lost wages and benefits over the casualties' remaining lifespan |
| Household productivity | Present value of lost productive household activity |
| **Indirect intangible human costs** | |
| Personal injury awards ascribed by the Transport Accident Commission of Victoria as a proxy for individual pain and suffering | |
| **Direct vehicle costs** | |
| Vehicle damage | Vehicle repair costs, towing costs and the cost of vehicle unavailability |
| **Direct general costs** | |
| Emergency services | Police and fire department response costs |
| Vehicle insurance claims | Costs of administering the motor vehicle property damage insurance system |
| Property damage | Cost of repairing roadside objects |
| Additional vehicle operating costs | Additional vehicle operating costs from extra time spent in congested traffic caused by road crashes |
| **Indirect general costs** | |
| Travel delays | Value of travel time losses |
| Health costs of additional local air pollution | Imputed additional health costs resulting from additional exhaust emissions from delays caused by a road crash |

*Source: Hendrie and Miller (2012:29) and Risbey et al. (2010:3)*

Risbey et al. (2010:3) group road crash costs broadly into fatality costs, injury costs as well as vehicle and other costs. The components of these three broad categories, namely fatality costs, injury costs and vehicle and other costs are summarised in Table 2.5.

**Table 2.5: Components of the cost of road crashes**

| Fatality costing | Injury costing | Vehicle and other costs |
|---|---|---|
| Workplace and household losses | Workplace and household output losses | Vehicle repairs and towing |
| Quality of life | Medical and other related costs | Vehicle unavailability |
| Pain, grief and suffering | Ambulance costs | Travel delays |
| Ambulance, police and other emergency services | Emergency services costs | Health costs of local air pollution |
| Hospital and medical | Long-term care cost | Additional vehicle operating costs |
| Coronial costs | Insurance administration cost | Vehicle insurance administration |
| Premature funeral | Legal costs | Repairing roadside objects |
| Workplace disruption and replacement | Workplace disruption costs | Costs of emergency services response |
| Insurance administration | Recruitment and re-training costs | |
| Correctional services (For the guilty offender) | Pain and suffering of people injured in crashes | |
| Legal costs | | |

Noteworthy is the fact that in addition to all cost components considered for USA estimates as reflected in Table 2.9, in the determination of the Australian road crash estimates, BITRE includes the following components as well:

- disability-related costs;
- recruitment and retraining costs;
- personal injury awards ascribed by the Transport Accident Commission of Victoria as a proxy for individual pain and suffering; and
- additional vehicle operating costs from extra time spent in congested traffic caused by road crashes to health costs of additional local air pollution.

It needs to be emphasised though that in keeping with HCA -based studies conducted in other countries, BITRE's assumptions are generally conservative and therefore tend to underestimate the cost of road crashes to society in Australia (Risbey et al., 2010:3; Tooth, 2010:4; Wren & Barrell; 2010:15). In order to demonstrate how the cost components were applied in real road crash cost assessments, Table 2.6 presents the social cost of road crashes in Australia by cost component, which in the case of Australia is referred to as 'cost element' (see BITRE, 2009). The cost components in Table 2.6 are divided into two categories, namely human-related costs and property damage and general costs. The human-related costs are further divided into costs of fatalities, costs of hospitalised injuries and costs of non-hospitalised injuries.

**Table 2.6: Estimated social costs of road crashes in Australia by cost element, 2006**

| Cost element | Human-related costs: Fatalities ($ millions) | Human-related costs: Hospitalised injuries ($ millions) | Human-related costs: Non-hospitalised injuries ($ millions) | Property damage and general costs ($ millions) | Total crash cost ($ millions) | Proportion (%) |
|---|---|---|---|---|---|---|
| Workplace and household losses | 3 007.2 | 2 573.9 | 108.9 | N/A | 5 690.0 | 31.9 |
| Repair costs | N/A | N/A | N/A | 4 227.5 | 4 227.5 | 23.7 |
| Disability-related costs[3] | N/A | 1 863.9 | N/A | N/A | 1 863.9 | 10.4 |
| Non-economic or non-pecuniary costs | 728.3 | 1 039.7 | N/A | N/A | 1 768.0 | 9.9 |
| Insurance administration | 13.2 | 256.5 | N/A | 1 421.3 | 1 691.0 | 9.5 |
| Medical and related costs | 3.4 | 511.4 | 349.5 | N/A | 864.2 | 4.8 |
| Travel delay and vehicle operating costs | N/A | N/A | N/A | 839.7 | 839.7 | 4.7 |
| Legal costs | 36.5 | 231.3 | N/A | N/A | 267.9 | 1.5 |
| Vehicle unavailability costs | N/A | N/A | N/A | 214.1 | 214.1 | 1.2 |
| Emergency and police services costs | 7.6 | 62.6 | N/A | 72.9 | 143.1 | 0.8 |
| Workplace disruption | 10.3 | 77.7 | N/A | N/A | 88.0 | 0.5 |
| Ambulance | 3.6 | 59.9 | N/A | N/A | 63.5 | 0.4 |
| Health cost of crash-induced pollution | N/A | N/A | N/A | 53.4 | 53.4 | 0.3 |

[3] Disability-related costs include the costs of future care, specialist accommodation, therapy and specialist services, day programmes, specialist equipment and alterations to houses.

| Cost element | Human-related costs: Fatalities ($ millions) | Human-related costs: Hospitalised injuries ($ millions) | Human-related costs: Non-hospitalised injuries ($ millions) | Property damage and general costs ($ millions) | Total crash cost ($ millions) | Proportion (%) |
|---|---|---|---|---|---|---|
| Damage cost of roadside objects | N/A | N/A | N/A | 40.2 | 40.2 | 0.2 |
| Correctional services (For guilty offenders) | 15.3 | N/A | N/A | N/A | 15.3 | 0.1 |
| Recruitment and re-training | 6.6 | 2.5 | N/A | N/A | 9.2 | 0.1 |
| Premature funeral cost | 7.2 | N/A | N/A | N/A | 7.2 | 0.0 |
| Coronial costs | 3.1 | N/A | N/A | N/A | 3.1 | 0.0 |
| Total | 3 842.4 | 6 679.5 | 458.3 | 6 869.1 | 17 849.3 | 100.0 |

Note: Components may not add to totals due to rounding; N/A = not applicable

*Source: BITRE (2009:84).*

Table 2.6 shows that workplace and household losses as well as repair costs account for the highest and second highest costs of the total cost, accounting for 31.9% and 23.7% respectively. Furthermore, it is evident from Table 2.6 that the social cost of road crashes was an estimated $17.85 billion (approximately R175 280 126 000 in South African rands) in 2006, which is 1.7% of the GDP for the base year (BITRE, 2009:84; Risbey et al., 2010:11).

Section 2.3.1.2 presents a discussion on the approach the Netherlands followed at the time of this research for the assessment of road traffic costs.

#### *2.3.1.2 Netherlands*

In 2009, the costs of road traffic crashes in the Netherlands amounted to €12.5 billion (R146 398 750 000 based on the 2009 average euro to South African rand [ZAR] exchange rate (Nedbank, nd), which accounted for 2.2% of the country's GDP (SWOV, 2014:1). This is in line with previous studies, which found that road traffic injury costs can reach 1.0%, 1.5% and 2.0% of GDP in low-income, middle-income and high-income countries, respectively (Pérez-Nŭňez, Hijar-Medina, Heredia-Pi, Jones & Silveira-Rodrigues, 2010:335).

According to international guidelines and state-of-the-art economic theory, human costs should be estimated using the WtPA (Wijnen, 2013:3). This means that the amount of money that people are prepared to pay for a reduction in crash risk should be estimated using either the SPM or the revealed preference method (RPM). The RPM values risk reductions on the basis of actual behaviour, for example purchasing behaviour regarding safety provisions, while the SPM uses questionnaires in which people are asked – directly or indirectly – how much they are willing to pay for safety provisions. From the WtP for risk reductions, the value of a statistical life (VoSL) is derived (Wijnen, 2013:3). The VoSL is comprised of the valuation of human costs as well as the value of consumption loss. Subtracting consumption loss from the VoSL therefore results in the value of human costs (Wijnen, 2013:3). For this reason, the WtPA was used in the calculation of human costs in the Netherlands.

The SWOV (2012:1) identifies seven cost categories for use in road traffic crash cost valuation. These cost components were used in estimating road crash costs using the 2009 road crash data. The categories are outlined in Table 2.7 (Hendrie & Miller, 2012:23).

Table 2.7 shows that, just as in the case of the United States (see Table 2.9) and Australia, cost components considered in road traffic crash assessment in the Netherlands fall into two categories, namely direct and indirect costs. It needs to be noted though that contrary to the

Australian practice, the direct non-medical human costs exclude vocational rehabilitation and workplace costs, and indirect tangible human costs exclude household productivity.

**Table 2.7: Cost categories in the Netherlands crash cost estimates**

| | |
|---|---|
| **Direct medical human costs** | |
| Medical | Includes hospital costs, rehabilitation, medicines and adaptations for people with disabilities |
| **Direct non-medical human costs** | |
| Vocational rehabilitation | Cost component not considered |
| Workplace costs | Cost component not considered |
| Insurance administration | Settlement costs include expenses incurred by organisations such as the fire brigade, police, law courts and insurers |
| Legal costs | See above – included under 'settlement costs' |
| **Indirect tangible human costs** | |
| Market productivity | Present discounted value of lost wages and benefits over the remaining life span of the casualties |
| Household productivity | Cost component not considered |
| **Indirect intangible human costs** | |
| Loss of quality of life | Amount people are willing to pay to avoid this loss of quality of life less the economic value of the consumption loss (the latter included in production loss) |
| **Direct vehicle costs** | |
| See below – included under 'property damage' | |
| **Direct general costs** | |
| Emergency services | See above – included under 'settlement costs' |
| Property damage | Value of damage to vehicle(s), freight, roads and fixed roadside objects |
| **Indirect general costs** | |
| Travel delays | Value of travel time delay due to traffic congestion |

In line with international guidelines, such as the European guideline COST 313 (see Kasnatscheew, Heinl, Schoenebeck, Lemer & Hosta, 2016), five components of the costs of road crashes are distinguished (Wijnen, 2013:3) (first five on the list that follows). However, SWOV adds congestion costs for inclusion under the components used for crash cost assessment. SWOV (2014:2–3) and Wijnen (2013:3) describe the cost components used in the assessment of crash costs in the Netherlands as follows:

- *Medical costs:* various data sources are used to determine these costs in the Netherlands, including data from the National Medical Register, the Injury Information System, the Accidents and Exercise in the Netherlands and Statistics Netherlands data This includes, for example, the average number of days that a casualty is hospitalised, the average costs per day of hospital or nursing home treatment and the annual number of ambulance trips. These are therefore costs resulting from the treatment of casualties, e.g. costs of hospital stay, rehabilitation, medicines and adaptations for the handicapped.

- *Production loss:* entails loss of production and income resulting from the temporary or permanent disability of the injured, and the complete loss of production of fatalities. The potential loss of production is calculated, i.e. the monetary value of the contribution somebody would have made had such person not been injured or killed. Here, it does not matter whether the individual casualties were actually employed before the crash, or would have been employed in the future (Wijnen, 2013:3). In the case of fatalities, the total value of production over the lost productive years as well as the present value is calculated, i.e. the production is weighted over those lost years. So far, no allowance has been made for unpaid work, such as domestic or voluntary work (Wijnen, 2013:3). However, the consumption loss of fatalities is included in the production costs (Wijnen, 2013:3).
- *Loss of quality of life:* these are immaterial costs as a result of suffering, pain, sorrow and loss of quality of life by casualties. To determine the human losses a survey was conducted in the Netherlands about the amount of money people are willing to pay for a certain reduction in the crash rate (De Blaeij, 2003). This study determined the so-called 'value of a statistical life' (VoSL) which is used to calculate the human losses (SWOV, 2014:2–3; Wijnen, 2013:3). The VoSL is corrected for the consumption loss of those killed, because these costs have already been included in the category production loss (SWOV, 2014:2–3; Wijnen, 2013:3.
- *Property damage:* refers to damage to vehicles, freights, roads and fixed roadside objects. However, the majority of property damage concerns damage to vehicles. The estimation of these costs is based on insurance data, such as damage claims paid, estimates of the damage not claimed, and damage not compensated (SWOV, 2014:2–3; Wijnen, 2013:3). One of the major problems regarding this cost component is the fact that not all damage is claimed, because of no-claim premiums for example, and that not all damage is covered by insurances.
- *Settlement costs:* in this category, costs of police, fire brigade, law courts and administrative costs of insurers are taken into account. Statistics Netherlands data (see Wijnen, 2013), data provided by the Dutch Research and Documentation Centre (WODC) of the Ministry of Security and Justice (see Wijnen, 2013), studies into the time spent by the police and insurance data are among the sources used to estimate these costs.

- *Congestion costs:* research data regarding the total traffic congestion costs and the share of lost time due to crashes is used to estimate these costs. The time loss due to traffic congestion as a result of crashes is based on data about congestion intensity. About 11% of the 2009 congestion intensity was the result of crashes (SWOV, 2014:2–3; Wijnen, 2013:3). Furthermore, a multiplication factor is used for the other costs resulting from congestion, such as costs caused by the unreliability of travel time.

The SWOV (2012:3) further asserts that the previously mentioned method of calculation and data gathering was used in the most recent studies into the cost of road crashes in the Netherlands (see Wijnen, Weijermars, Vanden Berghe, Schoeters, Bauer, Carnis, Elvik, Theofilatos, Filtness, Reed, Perez & Martensen, 2017; Wijnen et al, 2016). This method differs in several aspects from the methods that were used previously. Reasons for the differences are that data sources that were used previously are no longer available and/or that better calculation models have become available. Furthermore, the definitions of the different categories of casualties and crashes have been changed as a consequence of the new definition of serious road injuries (Wijnen et al, 2016:).

In order to demonstrate the application of the approach outlined, Table 2.8 summarises Dutch crash cost estimates over the years 2003, 2006 and 2009.

**Table 2.8: Social costs of road crashes (2003, 2006 and 2009 prices in million euros)**

| Cost category | 2003 | 2006 | 2009 |
|---|---|---|---|
| Medical costs | 320 | 311 | 352 |
| Property damage | 3 546 | 3 208 | 3 866 |
| Settlement costs | 1 162 | 1 272 | 1 293 |
| Production loss | 1 466 | 854 | 924 |
| Congestion costs | 337 | 241 | 300 |
| Human costs | 5 535 | 5 031 | 5 761 |
| **Total** | **12 360** | **10 920** | **12 500** |

*Source: SWOV (2014:3)*

It is evident from Table 2.8 that the 2009 research, which is the most recent study to estimate the costs of road crashes in the Netherlands, estimated the total crash costs to be €12.5 billion. Furthermore, Table 2.8 shows that the highest cost at that stage was accounted for by human costs (€5.8 billion), and property damage costs (€3.9 billion). The settlement costs amounted to €1.3 billion and the production loss accounted for €0.9 billion.

Medical costs and congestion costs constituted a relatively small proportion of the overall costs (€0.352 billion or 2.82% of the total 2009 social cost).

Property damage and human costs are the highest in this cost assessment, which is a confirmation of trends in the other four countries considered for the purpose of this review.

Road traffic crash cost assessment practices of the United States of America are discussed in section 2.3.1.3.

#### *2.3.1.3 United States of America*

The National Highway Traffic Safety Administration (NHTSA) produced their most recent report titled "The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised)" in May 2015 (Blincoe, Miller, Zaloshnja & Lawrence; 2015:5). This study found that in 2010:

- 32 999 people were killed on American roads;
- 3.9 million people were injured;
- 24 million vehicles were damaged in motor vehicle crashes;
- the economic costs of these crashes totalled $242 billion (i.e. R1 773 860 000 000 according to the 2010 average US$ to ZAR exchange rate of R7.33) (Nedbank, n.d.) and this amount represented an equivalent of nearly $784 (R5 746.72 at the 2010 average exchange rate of R7.33) (Nedbank, n.d.) for each of the 308.7 million people living in the United States at the time; and
- the total economic cost also represented 1.6% of the $14.96 trillion real GDP for 2010 in the United States (Blincoe et al., 2015:i).

The cost components included in the calculation of the crash cost estimates consisted of productivity losses, property damage, medical costs, rehabilitation costs, congestion costs, legal and court costs, emergency services, such as medical, police and fire services, insurance administration costs, and the costs to employers (Blincoe et al., 2015:1). Blincoe et al. (2015:12 & 287) categorised the following costs as components of the total economic costs of road traffic crashes:

- *Medical care*: the cost of all medical treatment associated with motor vehicle injuries including treatment given during ambulance transport. Medical costs in this case include emergency room and in-patient costs, follow-up visits, physical therapy, rehabilitation, prescriptions, prosthetic devices and home modifications.
- *Emergency medical services (EMS)*: this component consists of police and fire department response costs.
- *Market productivity*: the present discounted value future lost productivity (using a 3% discount rate for 2010 dollars).

- *Household productivity*: the present value of lost productive household activity, valued at the market price for hiring a person to accomplish the same tasks.
- *Insurance administration*: the administrative costs associated with processing insurance claims resulting from motor vehicle crashes and defence attorney costs.
- *Workplace costs*: the costs of workplace disruption due to the loss or absence of an employee. These include the cost of training new employees, retraining of the injured employee for placement in an alternative job, overtime required to accomplish work of the injured employee, and the administrative costs of processing personnel changes.
- *Legal costs*: the legal fees and court costs associated with civil litigation resulting from traffic crashes.
- *Congestion costs*: the value of travel delay, added fuel usage, greenhouse gas and criteria pollutants that result from congestion arising from motor vehicle crashes.
- *Property damage*: the value of vehicles, cargo, roadways and other items damaged in traffic crashes.

Hendrie and Miller (2012:21) describe the components referring to the 2002 National Highway Traffic Safety Administration crash cost assessment report (see Blincoe, Seay, Zaloshnja, Miller, Romano, Luchter & Spicer, 2002 as indicated in Table 2.9). It needs to be indicated that these cost categories are the same as those considered in Australia and the Netherlands (see Tables 2.4 and 2.7).

**Table 2.9: Cost categories in the US crash cost estimates**

| | |
|---|---|
| **Direct medical human costs** | |
| Medical costs | Include ambulance travel, emergency room and in-patient costs, follow-up visits, physical therapy, rehabilitation, prescriptions, prosthetic devices and home modifications |
| **Direct non-medical human costs** | |
| Vocational rehabilitation | Cost of job or career retraining required as a result of disability caused by motor vehicle injuries |
| Workplace costs | Costs of workplace disruption due to the loss or absence of an employee. This includes the cost of training new employees, and the administrative costs of processing personnel changes |
| Insurance administration | Administrative costs associated with processing insurance claims resulting from motor vehicle crashes and defence attorney costs |
| Legal costs | Legal fees and court cases associated with civil litigation resulting from traffic crashes |
| **Indirect tangible human costs** | |
| Market productivity | Present discounted value of the lost wages and benefits over the remaining lifespan of the casualties |
| Household productivity | The present value of lost productive household activity valued at the market price for hiring a person to accomplish the same tasks |

| | |
|---|---|
| **Direct vehicle costs** | |
| See property damage below | |
| **Direct general costs** | |
| Emergency medical services | Police and fire and rescue services |
| Property damage | Value of vehicles, cargo, roadways and other items damaged in traffic crashes |
| **Indirect general costs** | |
| Travel delays | Value of travel time delays for persons who are not involved in traffic crashes but who are delayed in the resulting traffic congestion from these crashes |

Blincoe et al. (2015:11–21) calculated four critical road traffic crash estimates: total economic costs, unit costs, total comprehensive costs as well as economic and societal costs for selected crash types. Total economic costs and total comprehensive costs are discussed below.

*(a) Total economic costs*

Total economic costs are summarised in Table 2.10. Injuries are rated at six levels of the maximum abbreviated injury scale (MAIS), namely MAIS0, MAIS1, MAIS2, MAIS3, MAIS4 and MAIS5. Of this total cost, medical costs account for $23.4 billion, property damage losses for $76.1 billion, lost productivity (for both market and household) for $77.4 billion, and congestion for $28 billion (Blincoe et al., 2015:5). It is also evident from Table 2.10 that property damage, market productivity, congestion and medical costs contributed 31%, 24%, 12% and 10% towards the total economic cost respectively in 2010. Therefore, property damage and market productivity contribute the most towards the overall economic costs of road crashes.

**Table 2.10: Summary of total economic costs (2010 prices in million US$)**

| Cost component | PDO Vehicle | MAIS0 | MAIS1 | MAIS2 | MAIS3 | MAIS4 | MAIS5 | Fatal | Total | % Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Medical | 0 | 0 | 9 682 | 3 879 | 4 898 | 2 329 | 2 209 | 373 | 23 372 | 9.7% |
| EMS | 518 | 96 | 308 | 66 | 42 | 14 | 5 | 30 | 1 079 | 0.4% |
| Market Productivity | 0 | 0 | 9 430 | 6 557 | 6 481 | 2 406 | 1 941 | 30 797 | 57 612 | 23.8% |
| Household Productivity | 1 111 | 206 | 2 982 | 2 407 | 2 286 | 641 | 548 | 9 567 | 19 748 | 8.2% |
| Insurance Administration | 3 535 | 655 | 11 408 | 1 578 | 1 548 | 482 | 417 | 935 | 20 559 | 8.5% |
| Workplace | 1 148 | 211 | 1 180 | 896 | 582 | 109 | 64 | 389 | 4 577 | 1.9% |
| Legal | 0 | 0 | 4 089 | 1 135 | 1 249 | 456 | 475 | 3 514 | 10 918 | 4.5% |
| **Subtotal** | 6 311 | 1 169 | 39 079 | 16 519 | 17 087 | 6 437 | 5 660 | 45 604 | 137 865 | 57.0% |
| Congestion | 19 934 | 3 483 | 3 836 | 405 | 144 | 26 | 9 | 189 | 28 027 | 11.6% |
| Property Damage. | 45 235 | 8 378 | 18 694 | 1 957 | 1 096 | 279 | 87 | 370 | 76 096 | 31.4% |
| **Subtotal** | 65 169 | 11 861 | 22 530 | 2 363 | 1 241 | 305 | 96 | 559 | 104 123 | 43.0% |
| **Total** | 71 480 | 13 030 | 61 608 | 18 881 | 18 327 | 6 742 | 5 755 | 46 163 | 241 988 | 100.0% |
| **% Total** | 29.5% | 5.4% | 25.5% | 7.8% | 7.6% | 2.8% | 2.4% | 19.1% | 100.0% | 0.0% |

*Source: Blincoe et al. (2015:11)*

The percentage distribution of total economic costs across cost components further shows that property damage-related costs are the highest (31.4%) followed by lost market productivity (23.8%) of the total economic costs in 2010. For lost productivity, these high costs are the result of the level of disability resulting from crashes involving injury and fatalities whereas for property damage, the high costs are a function of the very high incidence of minor crashes in which there were no injuries or where injury was negligible (Blincoe et al., 2015:5).

*(b) Total comprehensive costs, reported and unreported crashes in 2010 prices in million US dollars*

Table 2.11 provides a summary of total comprehensive costs for reported and unreported crashes in 2010 prices in million US dollars.

**Table 2.11: Summary of total comprehensive costs, reported and unreported crashes (2010 prices in million US$)**

| Cost component | Property Damage Only Vehicle | MAIS0 | MAIS1 | MAIS2 | MAIS3 | MAIS4 | MAIS5 | Fatal | Total | % Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Medical | 0 | 0 | 9 682 | 3 879 | 4 898 | 2 329 | 2 209 | 373 | 23 372 | 2.8% |
| Emergency Medical Services | 518 | 96 | 308 | 66 | 42 | 14 | 5 | 30 | 1 079 | 0.1% |
| Market Productivity | 0 | 0 | 9 430 | 6 557 | 6 481 | 2 406 | 1 941 | 30 797 | 57 612 | 6.9% |
| Household Productivity | 1 111 | 206 | 2 982 | 2 407 | 2 286 | 641 | 548 | 9 567 | 19 748 | 2.4% |
| Insurance | 3 535 | 655 | 11 408 | 1 578 | 1 548 | 482 | 417 | 935 | 20 559 | 2.5% |
| Workplace | 1 148 | 211 | 1 180 | 896 | 582 | 109 | 64 | 389 | 4 577 | 0.5% |
| Legal costs | 0 | 0 | 4 089 | 1 135 | 1 249 | 456 | 475 | 3 514 | 10 918 | 1.3% |
| **Subtotal** | **6 311** | **1 169** | **39 079** | **16 519** | **17 087** | **6 437** | **5 660** | **45 604** | **137 865** | **16.5%** |
| Congestion | 19 934 | 3 483 | 3 836 | 405 | 144 | 26 | 9 | 189 | 28 027 | 3.4% |
| Property damage | 45 235 | 8 378 | 18 694 | 1 957 | 1 096 | 279 | 87 | 370 | 76 096 | 9.1% |
| **Subtotal** | **65 169** | **11 861** | **22 530** | **2 363** | **1 241** | **305** | **96** | **559** | **104 123** | **12.5** |
| **Total** | **71 480** | **13 030** | **61 608** | **18 881** | **18 327** | **6 742** | **5 755** | **46 163** | **241 988** | **29.0%** |
| Quality Adjusted Life Years (QALYs) | 0 | 0 | 80 395 | 115 464 | 81 166 | 34 812 | 26 322 | 255 646 | 593 805 | 71.0% |
| **Comprehensive total** | **71 480** | **13 030** | **142 004** | **134 345** | **99 493** | **41 555** | **32 077** | **301 809** | **835 793** | **100.0%** |
| % Total | 8.6% | 1.6% | 17.0% | 16.1% | 11.9% | 5.0% | 3.8% | 36.1% | 100.0% | 0.0% |

*Source: Blincoe et al. (2015:16)*

Information in Table 2.11 shows that the inclusion of the lost quality of life for the life years that fatal crash victims lose make fatal crashes the most costly component of the total comprehensive costs. This is contrary to the instance summarised in Table 2.10 for the determination of the total economic costs, excluding the lost quality of life for the life years, in which case property damage only (PDO) crashes is the most costly.

#### *2.3.1.4 United Kingdom*

Estimates of road traffic crash costs in the United Kingdom (UK) are produced by the UK Department of Transport. Although police-reported figures are widely recognised as being an incomplete account of crashes and casualties, incidence data on crashes and casualties are drawn only from police records. Costs are presented for both casualties and crashes, and three levels of severity are identified, namely fatal, serious injury and slight injury (Hendrie & Miller, 2012:24). Just like expressly indicated in the case of the Netherlands, the United Kingdom has been using the WtPA in the determination of human costs since 1993. As such, in the cost estimates reported below, human costs are based on estimates of people's WtP for small reductions in the risk of exposure to such effects (United Kingdom Department for Transport, 2012:1).

Even though they consider the same cost categories as Australia, the Netherlands and the United States (see Tables 2.5, 2.7 and 2.9 above), the United Kingdom Department for Transport excludes from crash cost components vocational rehabilitation, workplace costs, household productivity and travel delays due to congestion resulting from road traffic crashes. This is evident in Table 2.12.

**Table 2.12: Cost categories in UK crash cost estimates**

| | |
|---|---|
| **Direct medical human costs** | |
| Medical | Includes ambulance, emergency department, hospital in-patient, blood transfusion services, district nurse services, cost of medical appliances and social security services |
| **Direct non-medical human costs** | |
| Vocational rehabilitation | Cost component not considered |
| Workplace costs | Cost component not considered |
| Insurance administration | Administrative costs |
| Legal costs | Cost component not considered |
| **Indirect tangible human costs** | |
| Market productivity | Present value of the expected loss of earnings plus non-wage payments made by employers |
| Household productivity | Cost component not considered |

| | |
|---|---|
| **Indirect intangible human costs** | |
| Loss of quality of life | Willingness to pay to avoid pain, grief and suffering to the casualty, relatives and friends as well as intrinsic loss of enjoyment of life in the case of fatalities |
| **Direct vehicle costs** | |
| See property damage below | |
| **Direct general costs** | |
| Emergency services | Police costs |
| Property damage | Cost of damage to vehicles and property and costs relating to the loss of use of the damaged vehicles and rental of a replacement vehicle |
| **Indirect general costs** | |
| Travel delays | Cost component not considered |

*Source: Hendrie and Miller (2012:24)*

In 2005, 2 913 fatal crashes, 25 029 serious crashes and 170 793 slight crashes were reported (United Kingdom Department for Transport, 2007:7). In cost–benefit terms, the value of prevention of these 198 735 injury accidents is estimated to have been £12 807 million in 2005 prices and values. Furthermore, there were an estimated 3 million damage-only crashes valued at £5 044 million meaning that this is the value of preventing the 3 million damage-only crashes. Therefore, the total value of prevention of all road crashes in 2005 was estimated to have been £17 851 million. It needs to be emphasised again that since 1993, the United Kingdom uses the WtPA to calculate human costs, which represent the *ex ante* benefit of avoidance of risk of a road crash, rather than *ex post* values of the consequences of a crash (United Kingdom Department for Transport, 2007:7; 2012:1). This approach encompasses all aspects of the valuation of casualties, including the human costs, which reflect, pain, grief and suffering, the direct economic costs of lost output, and the medical costs associated with road accident injuries. In addition to casualty-related costs for each crash, there are also costs related specifically to crashes, comprising damage to property, police costs, and the costs of insurance administration.

According to the Highways Economics Note No. 1, the United Kingdom Department for Transport (2007:11) provides estimates of the average values of crash prevention. In order to demonstrate how cost estimates are calculated in Great Britain, Table 2.13 provides these average values of prevention per road traffic crash by severity and element of cost.

Table 2.13 shows that there are four levels of crash severity, namely fatal crash, serious crash, slight injury crash and damage to property only crash. Cost elements are divided into casualty-related costs and accident-related costs. Casualty-related costs comprise lost output costs, medical and ambulance costs and human costs, whereas accident-related costs are composed of police costs, insurance and administration costs and damage to property costs.

**Table 2.13: Average value of prevention per crash by severity and element of cost: Great Britain (2005 prices in million pounds)**

| | Cost element | | | | | | |
|---|---|---|---|---|---|---|---|
| | Casualty-related costs | | | Accident-related costs | | | |
| **Crash severity** | **Lost output** | **Medical and ambulance** | **Human costs** | **Police cost** | **Insurance and admin** | **Damage to property** | **Total** |
| Fatal | 547 290 | 5 450 | 1 080 290 | 1 660 | 260 | 9 830 | 1 644 790 |
| Serious | 21 920 | 13 130 | 149 030 | 230 | 160 | 4 460 | 188 920 |
| Slight | 2 660 | 1 130 | 12 660 | 50 | 100 | 2 650 | 19 250 |
| All injury | 13 070 | 2 700 | 45 490 | 100 | 110 | 2 980 | 64 440 |
| Damage only | – | – | – | 3 | 50 | 1 660 | 1 710 |

*Source: United Kingdom Department for Transport (2007:11)*

**Lost output** is calculated as a measure of the loss of productive capacity of an individual as a result of an injury in a road crash, which is calculated per casualty for each level of severity (United Kingdom Department for Transport, 2007:11). **Medical and ambulance costs** are the estimated costs associated with a casualty's use of the ambulance service, hospital crash and emergency department costs, hospital in-patient costs and blood transfusion services. **Human costs** reflect the non-resource element of the costs associated with human life or the effects of injury, such as the pain and distress felt by the accident victim or his or her relatives, as well as the intrinsic loss of enjoyment of life in the case of fatalities (United Kingdom Department for Transport, 2012:2). Human costs are based on estimates of people's WtP for small reductions in the risk of exposure to such effects (United Kingdom Department for Transport, 2012:2). The aim of the WtPA is to estimate the individual's marginal rate of substitution between money and the good one is interested in. In this case, this is the reduction of the risk of being killed in a car crash (Maier, Gerking & Weiss, 1989:181).

It is evident from Table 2.13 that within casualty-related costs, human costs are the highest for the 2005 road crashes followed by lost output across all three crash severity categories. Damage to property accounts for the highest cost within the crash-related costs.

Table 2.14 provides total values of prevention of crashes by severity and element of cost. The same crash severity levels and cost elements considered in Table 2.13 also apply in Table 2.14.

**Table 2.14: Total[4] value of prevention of road crashes by severity and element of cost: United Kingdom 2005 (2005 prices in million pounds)**

| | Cost element | | | | | | |
|---|---|---|---|---|---|---|---|
| | Casualty-related costs | | | Accident-related costs | | | |
| **Accident severity** | **Lost output** | **Medical and ambulance** | **Human costs** | **Police cost** | **Insurance and admin** | **Damage to property** | **Total** |
| Fatal | 1 590 | 20 | 3 150 | 5 | 1 | 30 | 4 790 |
| Serious | 550 | 330 | 3 730 | 6 | 4 | 110 | 4 730 |
| Slight | 450 | 190 | 2 160 | 9 | 20 | 450 | 3 290 |
| All injury | 2 600 | 540 | 9 040 | 20 | 20 | 590 | 12 810 |
| Damage only | – | – | – | 9 | 140 | 4 890 | 5 040 |
| **All crashes** | **2 600** | **540** | **9 040** | **30** | **160** | **5 490** | **17 850** |

*United Kingdom Department for Transport (2007:13)*

The 2012 total values of prevention of road crashes by severity and element of cost are summarised in Table 2.15. There was a significant decline in the total value of prevention of road crashes in the 2012 values (see Table 2.15) compared to the 2005 cost of prevention of road crashes shown in Table 2.14.

[4] Note that totals may not equal the sum of their elements due to rounding.

**Table 2.15: Total[5] value of prevention of road crashes by severity and element of cost: United Kingdom 2012 (2012 prices in million pounds)**

| | Cost element | | | | | | |
|---|---|---|---|---|---|---|---|
| | Casualty-related costs | | | Accident-related costs | | | |
| Accident severity | Lost output | Medical and ambulance | Human costs | Police cost | Insurance and admin | Damage to property | Total |
| Fatal | 1 040 | 9 | 2 042 | 29 | 1 | 19 | 3 139 |
| Serious | 526 | 315 | 3 582 | 44 | 4 | 108 | 4 578 |
| Slight | 389 | 165 | 1 854 | 67 | 15 | 381 | 2 871 |
| All injury | 1 955 | 490 | 7 478 | 139 | 19 | 508 | 10 589 |
| Damage only | 0 | 0 | 0 | 77 | 124 | 4 332 | 4 533 |
| **All crashes** | **1 955** | **490** | **7 478** | **217** | **143** | **4 840** | **15 122** |

*Source: United Kingdom Department for Transport (2012:4)*

The reduction in the total costs of prevention from 2005 to 2012 could be a function of road safety interventions that resulted in declines in the number of casualties. These could be vehicle safety-related interventions, which do not put the focus on safe road users as is evident from the observed increase in damage to property-related costs of prevention (see Tables 2.13 and 2.14).

Section 2.3.1.5 discusses road crash cost assessment practices of the last of the five selected countries, namely Belgium.

#### *2.3.1.5 Belgium*

In an international comparison of the social costs of road crashes, Trawén, Maraste and Persson (2002:330) found that road crash cost data are not available for Belgium and, as a result, these costs are not considered in Belgian policymaking. Subsequent to this observation, De Brabander and Vereeck (2007) conducted the first study.

De Brabander and Vereeck (2007:717) assert that it is generally accepted that valuation of preventing road crashes consists of three different categories briefly explained below and summarised in Table 2.16.

- *Human losses*: this element is measured by the WtP to prevent an accident, which in turn is estimated via a RPM or SPM. For a fatal casualty, the WtP includes the discounted loss of consumption. However, following the (European) traditional methodology, consumption is part of the gross output loss. In order to avoid double

[5] Note that totals may not equal the sum of their elements due to rounding.

counting, consumption is subtracted from the WtP to avoid a road fatality and added to the net output loss. Since consumption is not lost for (non-fatally) injured casualties, the WtP to avoid a road injury does not include the value of lost consumption. Hence, there is no danger of double counting.

- *Production losses*: this element measures the loss of economic output. Since the victim's consumption is not lost by a non-fatal injury, it is gross output loss that is rightly taken into account. For fatal injuries, it is really net output that is lost. However, for reasons of international methodological comparison, gross output loss is applied for fatalities as well. Hence, the value of consumption lost by the victim of a fatal road crash is included in the production loss (and subtracted from the WtP).
- *Crash costs*: these comprise of medical costs, hospital visiting costs, accelerated funeral costs, property damage, administrative costs of insurance companies, litigation costs, police and fire department costs, and congestion costs. The former three relate directly to the occurrence of injuries; the latter five to the mere occurrence of a crash. Most of these costs lead to out-of-pocket expenses with the exception of the loss of interest on an accelerated funeral and congestion costs of private household road users.

Table 2.16 presents the three cost categories considered in the assessment of road crash costs in Belgium, namely human losses, production losses and accident costs in terms of injury costs as well as non-injury costs. It also provides the approach or cost components considered in the assessment of each one of the three cost categories. It needs to be emphasised that as in the case of the Netherlands and the United Kingdom, Belgium also uses the WtPA to estimate human costs (see Table 2.16).

Table 2.16 presents four road crash cost categories, namely human losses, production losses and the two road crash severity-related categories, namely injury costs and non-injury costs. The table also provides valuation methods used to assess the costs of each one of the cost categories.

**Table 2.16: Valuation of road crash cost categories**

| Cost category | Valuation method |
|---|---|
| Human losses | WtP to prevent the crash (minus consumption losses for fatal injuries) |
| Production losses | Gross output loss (permanent or temporary) |
| *Accidents* | |
| Injury costs | Medical costs<br>Hospital visiting costs<br>Accelerated funeral costs |
| Non-injury costs | Private property damage<br>Public property damage<br>Administrative costs of insurance companies<br>Private litigation costs<br>Public litigation costs<br>Intervention costs by the police and fire departments<br>Congestion costs |

*Source: De Brabander and Vereeck (2007:717)*

In the study by De Brabander and Vereeck (2007), the unit values of all three categories described above were calculated for road casualties and crashes that occurred in Belgium in 2002, which was the most recent year for which official accident data was available. The records published by the Nationaal Instituut voor Statistiek (NIS) are used to determine the number of injury crashes. The NIS does not provide information on property damage only (PDO) crashes though. As a result, a database provided by a major Belgian insurance company was also used to estimate the number of PDO crashes in Belgium. All valuations are expressed in 2004 prices at a discount rate of 4% (De Brander & Vereeck, 2007:718).

In order to demonstrate how the cost components above are used to estimate the costs of road crashes in Belgium, Table 2.17 summarises the unit values of preventing road crashes in Belgium in 2004 prices. It is clear that the huge social burden of road crashes is largely caused by human losses, production losses and medical costs, followed by property damage and the intervention costs of emergency services (De Brabander & Vereeck, 2007:723).

Table 2.17 shows that cost components are divided into three cost categories, namely losses per casualty, injury costs per casualty, and non-injury costs per crash. The table further breaks down cost estimates of each cost component by crash severity level, namely fatal crash, serious crash, slight crash and PDO crash.

**Table 2.17: Unit value of preventing road crashes in Belgium, 2002 (2004 prices in euro)**

| Cost component | Fatal | Serious | Slight | PDO |
|---|---|---|---|---|
| Losses per casualty | | | | |
| Human loss | 1 301 541 | 296 590 | 19 772 | - |
| Production loss | | | | |
| Temporary (22–57) | – | 6 764 | 356 | – |
| Permanent (< 22) | 1 138 628 | 551 158 | – | – |
| Permanent (22–57) | 821 189 | 447 581 | – | – |
| *Injury costs per casualty* | | | | |
| Medical cost | 5 781 | 21 519 | 961 | – |
| Hospital visiting cost | 95 | 722 | – | – |
| Accelerated funeral cost | 1 650 | – | – | – |
| *Non-injury costs per crash* | | | | |
| PDO | – | 5 437 | – | 2 330 |
| Public property damage | – | 6 | – | – |
| Administrative cost of insurance companies | – | 92 | – | – |
| Private litigation cost | – | 98 | – | – |
| Public litigation cost | – | 33 | – | 5 |
| Intervention cost by the police department | – | 25 | – | – |
| Intervention cost by the fire department | – | 810 | – | – |
| Congestion | – | 15 | – | – |

*Source: De Brabander and Vereeck (2007:725)*

It is evident from Table 2.18 that the value per prevented fatal casualty in Belgium was estimated at €2 004 799. Seriously and slightly injured road victims incurred losses and costs valued at €725 512 and €20 943 respectively. The total cost per (injury) crash also included the crash costs not directly incurred by the road victim. Furthermore, the human losses, production losses and medical costs had to be weighed on a crash basis. In a fatal road crash, for instance, more than one life is lost. This resulted in an average value of €2 355 763 per fatal crash.

**Table 2.18: Unit values of preventing road crashes per casualty and per crash in Belgium (2004 prices in euros)**

| Cost component | Fatal | Serious | Slight | PDO |
|---|---|---|---|---|
| Unit cost per casualty | 2 004 799 | 725 512 | 20 943 | – |
| Human loss | 1 301 541 | 296 590 | 19 772 | – |
| Production loss[6] | 695 732 | 406 681 | 210 | – |
| Medical cost | 5 781 | 21 519 | 961 | – |
| Hospital visiting cost | 95 | 722 | – | – |
| Accelerated funeral cost | 1 650 | – | – | – |
| Unit cost per accident[7] | 2 355 763 | 850 033 | 34 944 | 2 571 |
| Casualty-related costs | 2 349 247 | 843 517 | 28 428 | - |
| Accident-related costs | 6 516 | 6 516 | 6 516 | 2 571 |

*Source: De Brabander and Vereeck (2007:725)*

The values per serious and slight injury crashes were €850 033 and €34 944 respectively. Furthermore, given the incidence of injuries per injury crash, it can be inferred from Table 2.17 that the average value per prevented injury crash was €227 025.

Finally, Table 2.19 shows the total 2002 road crash cost in Belgium (2004 prices in euros) was €7 195 472 639 (which is R57 779 645 291.17 in 2004 prices and euro–ZAR exchange rate of R8.03 [Nedbank, n.d.]). Serious crashes and PDO crashes, accounted for 71.4% (€5 139 853 515) and 28.6% (€2 055 619 124) respectively.

[6] Weighted over the age categories.

[7] Given the distribution of injuries per injury crash.

**Table 2.19: Total costs of road crashes in Belgium, 2002 (2004 prices in euro)**

| Categories | Fatal | Serious | Slight | PDO | All |
|---|---|---|---|---|---|
| Production losses | | | | | |
| *Temporary (22–57)* | - | 32 240 223 | 11 904 041 | - | 44 144 264 |
| *Permanent (< 22)* | 276 685 238 | 1 213 614 917 | - | - | 1 490 300 155 |
| *Permanent (22–57)* | 664 530 200 | 2 133 370 510 | - | - | 2 797 900 710 |
| Medical costs | 7 821 693 | 177 693 930 | 54 545 339 | - | 239 468 462 |
| Hospital visiting costs | 128 535 | 5 492 060 | 0 | - | 6 070 595 |
| Accelerated funeral costs | 2 232 450 | - | - | - | 2 232 450 |
| Private property damage | | 466 951 308 | | 1 863 147 220 | 2 330 098 528 |
| Public property damage | | 515 304 | | 4 797 804 | 5 313 108 |
| Administrative costs of insurance companies | | 7 901 328 | | 73 556 328 | 81 467 656 |
| Private litigation costs | | 8 416 632 | | 78 364 132 | 86 780 764 |
| Public litigation costs | | 2 834 172 | | 3 998 170 | 6 832 342 |
| Intervention costs by the police departments | | 2 121 335 | | 19 750 960 | 21 872 295 |
| Intervention costs by the fire departments | | 69 566 040 | | - | 69 566 040 |
| Congestion costs | | 1 288 260 | | 11 994 510 | 13 282 770 |
| Total value | | 5 139 853 515 | | 2 055 619 124 | 7 195 472 639 |

*Source: De Brabander & Vereeck (2007:728)*

De Brabander and Vereeck's (2007:727) study clearly shows the immense human and economic burden of road safety in Belgium resulting in an estimated €7.2 billion (2.6% of the GDP) crash cost. Knowledge of the extent of the costs by policymakers and planners guides informed investment within financial limits of their budgets in interventions that seek to reduce the number of road crashes and casualties (De Brabander & Vereeck, 2007:727).

In summary, the application of the HCA in the road traffic crash cost assessment for the five countries shows that all the countries had a number of practices in common at the time, namely:

- *Cost categories*: road traffic crash cost valuation studies of four countries divide costs into direct and indirect costs. These countries are the United Kingdom, the Netherlands, Australia and the United States of America (see Tables 2.5, 2.7, 2.9 and 2.12). Direct costs are further divided into direct medical human costs, direct non-medical human costs, direct vehicle costs and direct general costs. Furthermore, indirect costs are also divided into indirect tangible human costs and indirect general costs.
- *Crash severity*: In determining the total costs of road traffic crashes in the United Kingdom, Belgium and Australia, the costs per cost component were disaggregated by crash severity level, that is fatal injury, serious injury, slight injury and property damage only (see Tables 2.13, 2.14 and 2.19). In Australia, these severity levels are referred to as fatalities, hospitalised injuries, non-hospitalised injuries and property damage and general costs respectively (see Table 2.6).
- *Cost components*: These are the seven cost components that are common across at least two of the five countries discussed above in terms of the cost components considered in the assessment of their road traffic crash costs, namely property damage costs, medical costs, congestion costs, production loss, legal costs, insurance administration and human costs.

The fourth secondary objective of this study aimed at structuring the components of and the relationship between the HCA discussed in 2.3.1 and the WtPA. In order to achieve this secondary objective as well as secondary objective 1, it was necessary to also review literature and discuss the components of the WtPA. These are discussed in section 2.3.2.

### 2.3.2 WtPA

According to Maier et al. (1989:181), the economic theory behind CBA suggests that the missing price information be substituted by the amount people are willing to pay for the respective ‘products’. Globally, there is a growing awareness that the WtPA is a conceptually satisfactory way of addressing the issue of crash loss savings contrary to the traditional techniques, which attempt to evaluate the lives of specific individuals. The WtPA or *ex ante* method is one of the approaches used in measuring the benefit of health and life-saving programmes even though the reliability and validity of survey responses to questions concerning the reduction of fatality or injury risks have been questioned (Giles, 2003:96; Muller & Reutzel; 1984:808). This method entails the use of surveys to measure people’s willingness to pay (WtP) or willingness to accept (WtA). WtP is the maximum amount of money an individual is prepared to give up to ensure that a proposed project is undertaken, that is, estimates from this approach represent society's willingness to pay to avoid the death, injury and damage outcomes of road crashes (Giles, 2003:96). Secondly, the *ex ante* method can be conceptualised in relation to potential compensation pay-outs for deteriorations in driving behaviours, vehicle crashworthiness, and/or the road environment. Estimates in this case represent society's willingness to accept the increased risk of premature death (Giles, 2003:96). Therefore, WtA is the minimum amount of monetary compensation the individual needs in order to accept voluntarily that the proposed project is not undertaken or what people are willing to accept for a reduction in safety or health (Wren & Barrell, 2010:16).

In countries such as the United Kingdom, a valuation based on WtP – that is the amount that individuals are willing to pay for a reduction in the risk of a fatal crash – replaced the approach that was based on loss of output, medical costs and an estimate of human costs (termed pain, grief and suffering) (O'Reilly et al., 1994:45). The United Kingdom added direct economic costs (net output and medical costs) to the WtP valuation to produce a total value of preventing a fatality. The WtPA is preferred over the other methods because it is considered to be theoretically sound, superior and more consistent with the principles of CBA, and in line with current thinking in road safety worldwide (O'Reilly et. al., 1994:45; Robinson, 1993:925). According to Andersson and Treich (2011:3), this approach assumes that individuals' preferences are the basis for economic welfare.

The WtPA is premised on the principle that policy analysis is forward-looking. As such, there is no need to value lives lost but rather the benefit of reducing further risk to life. This is achievable since people make decisions every day that trade off risks to their lives against other benefits and in doing so, they exhibit a willingness to pay for risk reduction. Information on this WtP enables policymakers to estimate the value of preventing a fatality also more commonly referred to as a VoSL (Tooth, 2010:1). Tooth (2010:1) further reports that more direct estimates of VoSL are obtained from studies using a WtPA which is based on peoples stated preferences (i.e. surveys) or revealed preferences (i.e. observed behaviour) on willingness to pay for reduced risks. The results of these studies have confirmed that the HCA has led to a significant underestimation of the VoSL.

A review of literature identified two countries that use the WtPA to estimate the VoSL in order to use the figure to estimate the cost of road crashes, namely Egypt and Singapore. In WtP-based road crash assessment studies conducted in Egypt and Singapore, Abdallah et al. (2016:12) and Le et al. (2011:3) respectively recommend that in order to strike a balance between using a reliable yet up-to-date method, both the CVM and the SPM should be used when using the WtPA in road crash cost valuation. Therefore, data collection instruments (questionnaires) first ask respondents contingent valuation questions that probe willingness to pay for risk reduction in two different scenarios differentiated by their risk reduction probabilities (Abdallah et al., 2016:12; Le et al., 2011:3). The contingent valuation questions are then followed by stated preference (SP) choice questions. Using both these methods is intended to increase the certainty of obtaining reliable results and enabling comparison of the road traffic crash cost estimates derived using both methods (Abdallah et al., 2016:12; Le et al., 2011:3).

Tooth (2010:12–13) and Wren and Barrell (2010:16) identify two methods of the WtPA for use in estimating the VoSL. These methods are based on stated preferences and revealed preferences, namely:

- *Stated preference* studies – involve asking people questions that can be used to elicit how much they are willing to pay for a small reduction in risk to life. As with consumer surveys, results can be very sensitive to survey design and a variety of methods have been used to address this challenge.
- *Revealed preference* studies – are based on observations of behaviour. The majority of these studies have been based on people's willingness to accept riskier road safety projects.

It is against this background that survey questionnaires used in studies to derive willingness to pay road crash costs mostly include the two techniques, namely CVM and SPM (Le et al., 2011:1; Abdallah et al., 2016:10). The next section presents an overview of what each one of these two methods entails.

#### ***2.3.2.1 Contingent valuation method (CVM)***

Policymakers are often interested in how the public values goods and services that are not traded in the marketplace (Andersson & Treich, 2011:3; Cawley, 2006:5; Le et al., 2011:2). Cawley (2006:5) further asserts that these values can be estimated using the CVM. The CVM involves the use of survey questionnaires to elicit hypothetical WtP information (Cawley, 2006:5; Hackett, 2010:156). In fact, the CVM is, by far, the most direct and intuitive method to derive values for non-market goods (Quah & Toh, 2011:14). It involves eliciting the maximum amount that people are willing to pay for welfare improvements and the minimum that they are willing to accept as compensation for welfare loss, to derive a demand curve for a good in question (Quah & Toh, 2011:14). The CVM entails direct questions that ask respondents to state how much they are willing to pay for a reduction in the risk of being killed in a road crash. According to Abdallah et al. (2016:13) and Le et al.

(2011:3), a questionnaire for this valuation method contains questions that fall within three broad categories:

- **Factual and other questions** concerning respondents' vehicle ownership profile, daily kilometres travelled as well as age, income and other personal information.
- **Perception questions** intend to test the quality of individual perception of transport risk concepts.
- **Valuation questions** intend to provide estimates of relevant marginal rates of substitution, relative to valuation of fatal road crashes or road crashes where injuries were sustained.

Cawley (2006:5–6) provides the following recommendations to maximise the reliability of Contingent Valuation (CV) estimates:

- use of a probability sample;
- using face-to-face or telephonic interviews instead of mail surveys;
- measuring WtP rather than WtA;[8]
- pretesting of the CV questionnaire;
- phrasing CV questions in the form of hypothetical referenda in which respondents are told how much they would have to pay in increased taxes if the measure passed, and they are then asked to cast a simple 'yes' or 'no' vote;
- providing a 'would not vote' option in addition to the 'yes' and 'no' vote options in the referendum;
- breaking down WtP by a variety of respondent characteristics, such as income, interest and attitudes; and
- reminding respondents of their actual budget constraints when considering their willingness to pay.

It needs to be indicated though that the CVM has not been without criticism. Amongst others, the method is criticised for measuring what people say they would do, which may be different from what they would actually do (Hanley, Shogren & White, 2013:62).

The SPM is briefly discussed next.

#### *2.3.2.2 Stated preference method (SPM)*

The SPM is a choice experiment method, which adopts a particular view on how demand for goods is best pictured, known as the 'characteristics theory of value' (Hanley et al.,

[8] 'Willingness to accept' refers to how much the person would have to receive as compensation for them to accept an increase in something that causes disutility. 'Willingness to pay' and 'willingness to accept' tend not to be equal because of the "endowment effect" (Cawley, 2006:5).

2013:66). The method provides a sophisticated technique for obtaining individuals' valuations by asking respondents using pairs of hypothetical but realistic scenarios trading different travel attributes such as travel time, cost and number of casualties to decide which alternative to choose (Abdallah et. al., 2016:15; Le et al., 2011:3). The results are then used to develop choice models for use in estimating road crash costs.

In designing stated preference (SP) experiments, it is necessary to determine how many different values or levels each of the variables included in the experiments should have. Abdallah et al. (2016:15) and Le et al. (2011:3) strongly recommend that the larger the number of levels, the more accurate a variable may be estimated but this has to be weighed against the larger number of scenarios needed. Furthermore, the way in which the different levels of each of the variables are combined must be carefully considered. It is important to ensure that the variables are combined in such a way that there are low to no correlations between them, otherwise multi-collinearity results culminating in estimation problems arising (Abdallah et al., 2016:15; Le et al., 2011:3). Good practice in determining how the different variables are combined advocate for the use of 'orthogonal' designs. An orthogonal design is a design where the correlation between the variables is zero (Abdallah et al., 2016:15; Le et al., 2011:3). It is against this background that Hanley et al. (2013:66–67) assert that designing a choice experiment is almost an art form since decisions must be taken on a great number of issues:

- which attributes to include;
- how to describe them to respondents;
- which levels are to be used for each attribute;
- which price or cost term will be used;
- how the attributes and levels are combined in choice sets;
- how many choice sets respondents can deal with; and
- how many choice options are included in each choice set.

In order for the SP design to derive the estimates of motor vehicle crash costs, both the Egyptian and Singaporean studies considered three variables: travel time, trip cost and number of crashes. A total of 27 scenarios were therefore needed, based on each variable having three levels. An example of the scenarios used is shown in Table 2.20.

**Table 2.20: Example of questionnaire scenarios**

| | Route A | Route B |
|---|---|---|
| Trip cost | 19 | 28 |
| Journey time in busy condition (minutes) | 20 | 45 |
| Number of fatalities per annum | 42 | 27 |
| Given these options, I would choose | A | B |

It needs to be emphasised that, in order to ensure that the designs are robust, it is critical to ensure that the designs contain a good range of trade-offs and that the implied boundary values cover a good range. The levels need to be as realistic as possible to respondents' real-life experiences.

In the Egyptian study, Abdallah et al. (2016:16) also applied a multinomial logit (MNL) model (see Abdallah et al., 2016) to estimate the model for car user behaviour in terms of choices they make. Through this model, the significance of the parameters was also determined and the goodness of fit of the model was measured by rho squared. The quality of the tested model was therefore judged by a combination of the adjusted $r^2$ and the significance of the different coefficients at three acceptable levels, 99.9%, 99% and 95% and variables which did not fulfil this significance had to be excluded (Bergmann, 2007:276). In both the Egyptian and Singaporean studies, values for avoided fatal casualties were derived by dividing the relevant accident parameter by the trip cost parameters (Bergmann, 2007:276). Estimates of the VoSL were obtained by multiplying WtP values per trip by the average annual traffic volume on the road network (Abdallah et al., 2016:16; Le et al., 2011:12). In order to calculate the overall cost of the life loss in Egypt, the VoSL was multiplied by the total number of fatalities for the base year (2014) (Abdallah et al., 2016:17).

## 2.4 RATIONALE FOR THE CHOICE OF THE HCA AND THE WTPA FOR THIS STUDY

Five of the seven countries reviewed use the HCA and the other two use the WtPA in the estimation of the costs of road crashes. However, previous literature advocates for the use of the WtPA for this purpose, and this is supported by the increasing number of countries that use this approach. The common use of these two approaches makes it necessary to compare them to establish the strengths and weaknesses of each.

On the other hand, the HCA or *ex post* valuation of road crash costs considers life as an investment with potential future returns. When an investment is lost, a stream of potential returns is also lost (Giles, 2003:100). The individual is the focal point. De Beers and Van Niekerk (2004:25) compares the two approaches in terms of their advantages and disadvantages as reflected in Table 2.21.

**Table 2.21: Advantages and disadvantages of the HCA and WtPA**

| Approach | Advantages | Disadvantages |
|---|---|---|
| **Human capital approach** | Data more reliable and available than in the case of the WtPA | Values some lives higher than others due to labour market inequities, such as wage discrimination. Simplistically applied, the very young and old are undervalued |
| | Consistent and transparent results | Overestimates costs in an economy with less than full employment |
| | Simple to use | Does not reflect a key reason for investment in safety; aversion to death/injury rather than income protection |
| | | Ignores the loss of 'joy of life', while values for pain, suffering and grief are often arbitrary |
| | | Actuarial uncertainties regarding life expectancy and earnings |
| | | Selection of appropriate discount rate is controversial |
| **Willingness to pay approach** | Comprehensive | People have difficulty understanding and valuing small risks (generally less than 1 in 10 000) |
| | Incorporates subjective welfare costs | Individual perceptions of risk may differ |
| | Reflects individual preferences | Methodological difficulties (e.g. inaccurate responses) and strategic behaviour in surveys |
| | | Equity is not taken into account |
| | | Discrepancy in results using WtP and WtA |
| | | Values will change with income and variations in road safety |

*Source: De Beer and Van Niekerk (2004:25).*

The HCA (gross output) of assessing road crashes is preferred by the Asian Development Bank (ADB) and the TRL of the United Kingdom for use in developing countries (De Beer & Van Niekerk, 2004:1; De Leon et al., 2005:3185; TRL, 1995:4). However, Tooth (2010:4) concluded that for policy analysis in all transport modes, values used should reflect the WtP-based approach rather than the HCA, which undervalues life, which is common practice in other areas and other developed countries. Wren and Barrell (2010:15) report that the HCA does not measure the intangible costs of pain and suffering or loss of quality of life and it is also criticised for underestimating the value of life of children and the elderly because it values life using market earnings, which are lower for these population groups. This is supported by Giles (2003:95) with reference to the Australian case thus:

Estimation of road crash costs in Australia over recent decades are deficient for two reasons. First, such estimations use an *ex post* (human capital) approach, despite economic theory recommending the *ex ante* (willingness to pay) approach as the preferred means of placing dollar values on lives saved. Second, if the human capital approach is used in the absence of *ex ante* measures, then the derivation of human capital (forgone earnings) measures needs to comprehend factors such as age and gender, educational attainment, labour force experience and sector of employment, which are currently ignored.

In support of Giles' (2003:95) assertion, Tooth (2010:7) says the following on valuing of life, "if we go back to first principles, the economic value of the benefit of any policy outcome is society's willingness to pay for the benefit".

In keeping with the arguments by Giles (2003:95) and Tooth (2010:7), Maier et al. (1989:181) assert that the economic theory behind CBA suggests that the missing price information be substituted by the amount people are willing to pay for the respective 'products'. Maier et al. (1989:181) further report that internationally, there is a growing awareness that this WtPA is a conceptually more satisfactory way of addressing the issue of road crash loss savings than the traditional techniques, such as the HCA, which attempt to evaluate the lives of specific individuals.

## 2.5 CONCLUSION

This chapter provided an international perspective derived from the review of literature required to achieve secondary objective 1 and secondary objective 4. The literature review found that countries either use the HCA or the WtPA to estimate road crash costs. It was further established that there is a move globally in strong support of the latter.

The literature review further identified numerous generic cost components that are globally considered in estimating road crash costs using the HCA. In particular, the literature review established that there are seven cost components that are common across at least two countries, namely property damage costs, medical costs, congestion costs, production loss costs, legal costs, insurance administration and human costs. The components are grouped into two broad categories depending on whether they are direct or indirect costs (see Tables 2.5, 2.7, 2.9 and 2.12). Direct costs are further divided into direct medical human costs, direct non-medical human costs, direct vehicle costs and direct general costs. Indirect costs consist of two further types, namely indirect intangible human costs and indirect general costs. In road traffic crash cost assessment studies done in the United Kingdom, Belgium and Australia, costs per cost component were disaggregated by crash severity level, namely fatal injuries, serious injuries, slight injuries and property damage only (see Tables 2.13, 2.14 and 2.19).

In Australia, the Transport Accident Commission (TAC) compensation figures are treated as proxies for human costs. However, other countries, such as the Netherlands, Belgium, the United States and the United Kingdom use the WtPA to calculate human costs. Noteworthy is also the fact that different countries do not necessarily include all the generally accepted cost components in their valuation of crash costs. The reason for exclusion of components is either due to non-availability of data or to insignificance of the impact the inclusion of such cost components will make on the overall cost estimate.

Two studies that used the WtPA entirely in the valuation of road crash costs in Egypt and Singapore were also reviewed. In particular, the studies used two methods of the WtPA, namely the CVM and the SPM. The study conducted in Egypt also used the MNL model to determine the extent to which respondents' willingness to pay for reduction in the risk of injury or death in road crashes is explained by the independent variables considered, namely travel cost, time and number of injuries or fatalities per year.

The next chapter presents a review of literature on road crash trends in South Africa as well as previous studies conducted to estimate the cost of road crashes in the country.

# CHAPTER 3:

# A SOUTH AFRICAN PERSPECTIVE ON ROAD CRASH STATISTICS AND ROAD TRAFFIC CRASH ASSESSMENT

## 3.1 INTRODUCTION

In this chapter, an SA perspective on the state of road safety as well as road traffic crash assessment practices is presented focusing on the first and fourth secondary objectives, namely:

- *Secondary objective 1*: to provide a literature review on international best practice in the assessment of the cost of road traffic crashes.
- *Secondary objective 4*: to structure the components of, and the relationship between, the HCA and the WtPA.

The structure of the chapter is depicted by Figure 3.1.

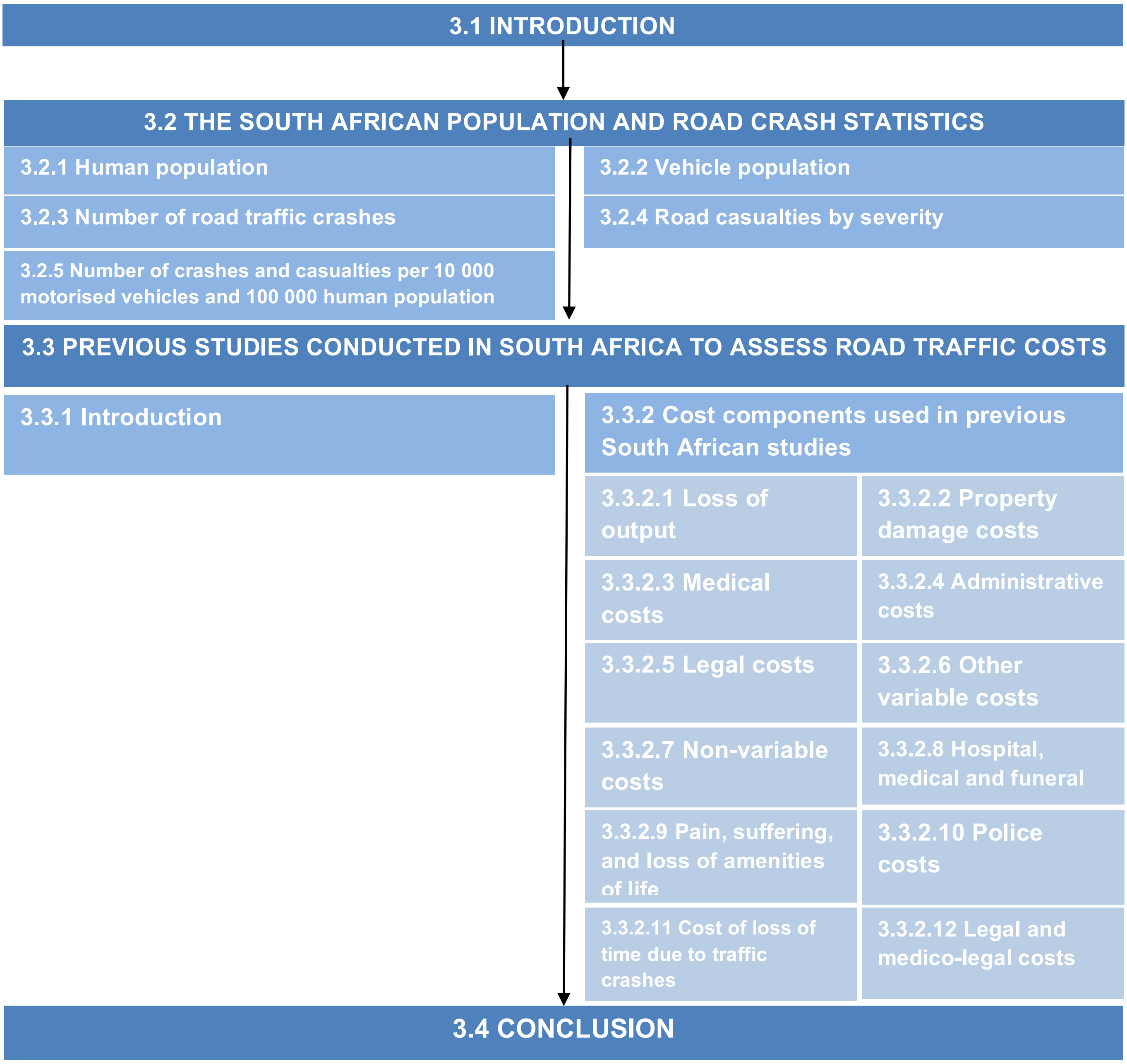


**Figure 3.1: Diagrammatic representation of the structure of Chapter 3**

Figure 3.1 depicts the flow of the chapter. The chapter is discussed in four sections, namely sections 3.1, 3.2, 3.3 and 3.4. The chapter starts with an introduction in section 3.1 explaining how the literature review presented in this chapter contributed towards the achievement of secondary objectives 1 and 4 (see section 1.3.2). Section 3.2 presents and discusses the SA population and road crash statistics. This information is critical in the determination of a country's road safety performance, particularly in the calculation of such statistics as the number of crashes and casualties per 10 000 motorised vehicles and 100 000 human population as it will become evident in section 3.2.5 below. This section consists of five sub-sections: human population (3.2.1), vehicle population (3.2.2), number of road traffic crashes (3.2.3), road casualties by severity (3.2.4) and the number of crashes and casualties per 10 000 motorised vehicles and 100 000 human population (3.2.5). Prior to the conclusion of the chapter (section 3.4), Chapter 3 presents a detailed review of literature focusing on previous studies conducted in South Africa to assess the costs of road traffic crashes. This review was fundamental in bringing an SA perspective to the achievement of two objectives of this study, namely secondary objectives 1 and 4 (see section 1.3.2 for the secondary objectives of this study).

In section 3.3, a review of literature on previous studies is reflected. This literature study was used to determine estimates of road crash costs in South Africa. Section 3.3 details approaches used in each of the studies conducted in terms of cost categories and components considered thus demonstrating how the approach(es) evolved from study to study in line with developments globally. The chapter concludes by comparing road traffic crash cost estimates in each of the previous studies.

This chapter forms the foundation of Chapter 4, which entails the methodology used in this study.

## 3.2 THE SOUTH AFRICAN POPULATION AND ROAD CRASH STATISTICS

This section presents a detailed account of the state of road safety in South Africa. This is done by providing the historical South African statistics in terms of human population, vehicle population, road crashes, road casualties (both injuries and fatalities) as well as road safety performance statistics, such as fatalities per 100 000 inhabitants, fatalities per 100 000 vehicle population and crash severity rates. In order to measure road safety performance and compare safety levels across countries, three indicators are commonly used (International Traffic Safety Data and Analysis Group [IRTAD], 2017:7), namely the number of fatalities per:

- head of population (mortality rate);
- distance travelled by motorised vehicles, that is vehicle kilometres (fatality risk); and
- registered motorised vehicles.

These statistics were used to position the study in terms of the extent of the road safety problem in South Africa, but also to depict the context within which these crashes and injuries occur commencing with the human population, vehicle population and number of road traffic crashes, amongst others.

### 3.2.1 Human population

Human population statistics play a crucial role in the calculation of statistics used to measure a country's road safety performance, such as road fatalities per 100 000 inhabitants, road fatalities per 100 000 motor vehicles and road fatalities per 10 000 motorised vehicles; amongst others. These statistics also place the road safety challenge that a country faces within the context of its population size. It is against this background that Table 3.1 presents the SA human population, which was used to calculate some of these road safety performance statistics for the country. Table 3.1 shows the growth in the SA population over a five-year period from 2013 to 2017, with the latter the base year for the purpose of this study.

**Table 3.1: South African human population (2013–2017)**

| Year | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---:|---:|---:|---:|---:|
| Human population | 52 982 000 | 54 002 000 | 54 956 900 | 55 908 900 | 56 521 900 |

***Source:*** *Stats SA (2013:3; 2014:3; 2015:2; 2016:2; 2017:2).*

It is evident from Table 3.1 that the population of South Africa grew by 6.7% between 2013 and 2017. Overall, the 2017 SA population was 6.7% (3 539 900 more inhabitants) higher than it was in the year 2013. This had implications on the number of both road fatalities and fatal crashes per 100 000 inhabitants as is evident in sections 3.2.2 and 3.2.3. The focus on the five years in Table 3.1 is intended to demonstrate trends over this period since the current study estimated costs of crashes for the year 2017 using the HCA and the WtPA.

For purposes of calculating the road safety performance statistics referred to above, the number of vehicles owned by SA citizens is also important. Therefore, the next section presents vehicle population statistics that were used in the calculation of road safety performance statistics.

### 3.2.2 Vehicle population

'Vehicle population' refers to the number of registered vehicles, both motorised and non-motorised, in a country (RTMC, 2013:11; 2014:11; 2015:10; 2016:10; 2017:33). These statistics are needed in the calculation of fatal crashes and fatalities per 10 000 and 100 000 vehicles, particularly for motorised vehicles. Table 3.2 provides SA vehicle population figures for the years 2013 to 2017. Of particular interest for this study are the figures for the year 2017 since this was the base year for this study.

**Table 3.2: South African vehicle population (2013–2017)**

| Year | Vehicle population | |
|---|---|---|
| | **Total** | **Motorised** |
| **2013** | 11 006 184 | 9 909 923 |
| **2014** | 13 369 925 | 10 249 504 |
| **2015** | 11 710 756 | 10 565 967 |
| **2016** | 11 964 234 | 10 801 558 |
| **2017** | 12 205 112 | 11 028 193 |

*Source: RTMC (2013:11; 2014:11; 2015:10; 2016:10; 2017:33)*

Table 3.2 shows that the population of motorised vehicles increased by 11.3% (thus an additional 1 118 270) between 2013 and 2017. Growth in vehicle population has implications on road network service levels since it leads to congestion if not growing in proportion to increased road network capacity and, as indicated at the beginning of this section, it also affects ratios of fatal crashes and fatalities per 100 000 or 10 000 vehicle populations.

Once both human and vehicle population statistics have been obtained, the second-last critical statistics required to be able to calculate road safety performance statistics reflect the number of road traffic crashes. These statistics are presented in section 3.2.3 below.

### 3.2.3 Number of road traffic crashes

The number of road traffic crashes serves a multiplicity of purposes in road traffic safety management. Amongst others, it is used in the:

- calculation of road traffic safety performance statistics together with the human and vehicle population statistics discussed above;
- planning of targeted interventions aimed at addressing the road safety challenge of a country;
- determination of road traffic safety trends over time; and
- assessment of road traffic crash costs.

However, for the purpose of this study, the first and the fourth uses are the most critical (i.e. calculation of road traffic safety performance statistics and assessment of road traffic crash costs).

The number of crashes are categorised by severity into four groups (fatal, major, minor and damage only). This represents one of the critical statistics in the assessment of the cost of road crashes since it enables estimation of costs under each of the four categories.

According to Labuschagne (2016:32), historical SA trends with regard to road traffic crashes indicate that the ratio of:

- major road traffic crashes to fatal road traffic crashes is 3.6:1;
- minor to fatal crashes is 11.9:1; and
- damage only to fatal crashes is 58.2:1.

Considering the number of fatal crashes as the base figure, these ratios were used to estimate the number of crashes for each one of the three severity categories for the years 2013, 2014, 2015, 2016 and 2017. Statistics on the numbers of fatal crashes were obtained from RTMC Road Traffic Calendar Reports for each of these years (see RTMC, 2013; 2014; 2015; 2016; 2017). Table 3.3 provides the statistics for the five years disaggregated by severity level.

**Table 3.3: Number of road traffic crashes: 2013–2017**

| | Number of road traffic crashes | | | | |
|---|---|---|---|---|---|
| **Year** | **Fatal** | **Major** | **Minor** | **Damage only** | **Total** |
| **2013** | 10 170 | 36 612 | 121 023 | 591 894 | 759 699 |
| **2014** | 10 367 | 37 321 | 123 367 | 603 359 | 774 414 |
| **2015** | 10 613 | 38 207 | 126 295 | 617 677 | 792 792 |
| **2016** | 11 676 | 42 034 | 138 944 | 679 543 | 872 192 |
| **2017** | 11 437 | 41 173 | 136 100 | 665 633 | 854 343 |

*Source: Adapted from the RTMC Road Traffic Calendar Reports (RTMC, 2013; 2014; 2015; 2016; 2017)*

With the exception of the year 2017, statistics in Table 3.3 show a steady increase in the overall number of road traffic crashes as well as for each of the four crash severity categories. Damage only crashes are the highest followed by minor crashes. In line with international trends (BITRE, 2009:10; Ghadi, Török & Tànczos, 2018:129; Risbey et al., 2010:4; Wijnen et al., 2016:19), fatal crashes are the lowest even though unacceptably high compared to the countries that were reviewed in Chapter 2 (see sections 2.3.1.1 to 2.3.1.2). The observation that crashes show a steady increase both overall and by category means that the cost of road crashes continues to increase astronomically in proportion to the huge increases in the number of casualties as indicated in Table 3.3. In the SA case, this calls for a need for interventions to reverse this trend. However, resource allocation for these countermeasures needs to be supported by sound economic evidence. It is for this reason that there is a need for studies such as this one to assess the costs of road crashes to bring SA resource allocation in line with the international norm.

The fourth and last statistics (i.e. those required to calculate road safety performance statistics as well as to assess the cost of road traffic crashes) reflect the number of road traffic casualties. These are discussed in section 3.2.4.

### 3.2.4 Road casualties by severity

Road crashes result in injury casualties (Bhalla et al., 2009; Hejazi et al., 2013:152). Just as is the case with crashes, casualties are divided into three categories in line with the extent of the injury, namely fatal, serious and slight injuries. According to Labuschagne (2016:32), historical SA road traffic crash injury trends indicate that the ratio of:

- major road traffic injuries to fatal road injuries is 4.6:1; and
- minor to fatal injuries is 14.9:1.

These ratios were used for the purpose of this study to estimate the number of casualties for each of the other two severity categories (i.e. major and minor injuries) for the years 2013–2017 using the number of fatal injuries from the RTMC Road Traffic Calendar Reports for each of these years. Table 3.4 summarises these casualty statistics according to the three injury severity categories, namely fatal, major and minor injuries.

**Table 3.4: Number of casualties by severity**

| Year | Number of road traffic injuries by severity | | | |
|---|---|---|---|---|
| | Fatal | Major | Minor | Total |
| **2013** | 11 844 | 54 482 | 176 476 | 242 802 |
| **2014** | 12 702 | 58 429 | 189 260 | 26 0391 |
| **2015** | 12 944 | 59 542 | 192 866 | 265 352 |
| **2016** | 14 071 | 64 727 | 209 658 | 288 456 |
| **2017** | 14 050 | 64 630 | 209 345 | 288 025 |

*Source: Adapted from the RTMC Road Traffic Calendar Reports (RTMC, 2013; 2014; 2015; 2016; 2017).*

According to Table 3.4, minor or slight injuries account for the majority of casualties followed by major or serious injuries for all five years considered. Despite the observation that fatalities account for the least of the three categories of casualties, fatalities remain unacceptably high relative to those of countries that have proved to have very good road safety records, such as those reviewed in Chapter 2 (see sections 2.3.1.1–2.3.1.5). Casualty figures shown in Table 3.4 further emphasise the challenge posed by road crashes for the economy, the health system and society in general in South Africa. This therefore makes a compelling case for immediate attention through investment in infrastructure, law enforcement and road safety campaigns, amongst others.

Now that all the statistics required to calculate ratios used to measure road safety performance of a country have been provided in sections 3.2.1–3.2.4, it is possible to calculate the ratios themselves. The next section presents and discusses these ratios.

### 3.2.5 Number of crashes and casualties per 10 000 motorised vehicles and 100 000 human population

A number of ratios, such as fatalities per 100 000 population and fatalities per 10 000 motorised vehicles, amongst others, are used to measure road traffic safety performance of a country (IRTAD, 2013:7; 2017:7). Amongst others, the IRTAD (2013:7; 2017:7) identifies the following ratios:

- road crash fatalities per 100 000 population;
  and
- road crash fatalities per 10 000 registered (motorised) vehicles.

The indicators above can therefore be used to compare road traffic safety performance between countries with similar traffic and car-use characteristics (IRTAD, 2013:7; 2017:7). It needs to be emphasised that road traffic safety performance measurement requires reliable statistics on the number of vehicles. In some countries, scrapped vehicles are not systematically removed from the registration database, which undermines accuracy. This indicator does not take into account non-motorised vehicles (such as bicycles), which can represent a large part of the vehicle fleet and of the fatalities figures in some countries. It is also worth noting that analysis in terms of fatalities over distance travelled is a very useful indicator for assessing the risk of travelling on the road network (Feleke, Scholes, Wardlaw & Mindell, 2018:309).

Against this background, Table 3.5 presents some of the ratios commonly used to assess the level of road safety risk, namely the number of:

- crashes per 10 000 motorised vehicles;
- fatal crashes per 10 000 motorised vehicles;
- casualty crashes per 10 000 motorised vehicles;
- fatalities per 100 000 human population; and
- casualties per 100 000 human population.

**Table 3.5: Number of crashes and casualties per 10 000 motorised vehicles and 100 000 human population**

| Year | No. of all crashes per 10 000 motorised vehicles | No. of fatal crashes per 10 000 motorised vehicles | No. of casualty crashes per 10 000 motorised vehicles | No. of fatalities per 100 000 human population | No. of casualties per 100 000 human population |
|---|---|---|---|---|---|
| **2013** | 766.6 | 10.3 | 169.3 | 22.4 | 458.3 |
| **2014** | 755.6 | 10.1 | 166.9 | 23.5 | 482.2 |
| **2015** | 750.3 | 10.0 | 165.7 | 23.6 | 482.8 |
| **2016** | 807.5 | 10.8 | 178.4 | 25.2 | 516.0 |
| **2017** | 774.7 | 10.3 | 171.1 | 24.9 | 509.6 |

*Source: RTMC (2013; 2014; 2015; 2016; 2017) and Stats SA (2013; 2014; 2015; 2016; 2017).*

It is evident from Table 3.5 that South Africa saw a steady decrease in road crashes year-on-year per 10 000 motorised vehicles between 2013 and 2015. However, there was a drastic increase in 2016, which again decreased in 2017. Furthermore, for every 10 000 motorised vehicles, 10.3 were involved in a fatal crash in 2013, and this figure decreased to 10.0 in 2015 followed by a drastic increase to 10.8 in 2016, which again decreased to 10.3 in 2017. This shows that South Africa has performed poorly with regard to road traffic safety. Table 3.5 further shows that for every 10 000 motorised vehicles, about 169 were involved in a vehicle crash in 2013, which is a relatively high casualty rate compared to a marginally lower 165.7 vehicles that were involved in traffic crashes in 2017.

According to Table 3.5, for every 100 000 SA inhabitants, about 25 were involved in fatal crashes in 2016 compared to 22 in 2013, even though a slight decrease was recorded from 25.2 in 2016 to 24.9 in 2017. Compared to four of the five countries selected for the literature review to provide an international perspective in Chapter 2, namely Australia (5.6 fatalities per 100 000 inhabitants) (see WHO, 2015), Belgium (7.2 fatalities per 100 000 inhabitants) (see WHO, 2015), the Netherlands (3.9 fatalities per 100 000 inhabitants) (see WHO, 2015) and the United Kingdom (3.5 fatalities per 100 000 inhabitants) (see WHO, 2015) (also see Table 2.3). Furthermore, for every 100 000 inhabitants in South Africa, the number of people that were involved in casualty crashes increased from about 458 in 2013 to about 516 in 2016 (see RTMC, 2013; 2014; 2015; 2016), which is indicative of increased risk on SA roads (see Table 3.5). However, a 6.4 decrease was recorded in 2017 (see RTMC, 2017); thus, reducing the number of injuries for every 100 000 inhabitants from 516 to 509.6, which is still a very high risk of road injury compared to the 2013 figure of 458 (see RTMC, 2013) (see Table 3.5).

In summary, the following can be concluded:

- the SA population grew by 6.7% between 2013 and 2017 (see Stats SA, 2013; 2014; 2015; 2016; 2017) (see Table 3.1);
- the population of motorised vehicles increased by 11.3% (1 118 270) between 2013 and 2017 (see RTMC, 2013; 2014; 2015; 2016; 2017) (see Table 3.2);
- there was a steady increase in the overall number of road traffic crashes as well as for each of the crash severity categories with the exception of 2017, which registered a slight decline compared to the 2016 figures, both overall and for each of the crash severity categories individually (see RTMC, 2013; 2014; 2015; 2016; 2017) (see Table 3.3);
- there was a steady increase in the overall number of road traffic casualties as well as per injury severity, except in 2017, when a decline was recorded compared to the 2016 casualties (see RTMC, 2013; 2014; 2015; 2016; 2017) (see Table 3.4); and
- the SA road safety performance ratios show that the country performs poorly compared to four of the five countries for which literature was reviewed in Chapter 2, namely Australia, Belgium, the Netherlands and the United Kingdom.

The road safety performance indicators in Table 3.6 further justify the need to allocate resources in proportion to the magnitude of the road safety challenge in South Africa.

The next section provides a review of previous studies conducted in South Africa to estimate the cost of road traffic crashes.

## 3.3 PREVIOUS STUDIES CONDUCTED TO ASSESS CRASH COST ESTIMATES IN SOUTH AFRICA

Secondary objectives 1 and 4 of this study aimed to respectively –

- conceptualise a literature review on international best practice in the assessment of the cost of road traffic crashes; and
- structure the components of, and the relationship between, the HCA and the WtPA.

The literature review of international practice was intended to inform the enhancement of the approach used to assess the cost of crashes in South Africa. It is therefore also necessary to trace how the road traffic crash cost valuation approach(es) used in South Africa evolved over time starting from the very first to the most recent study conducted in the country. This section therefore intends to add an SA perspective to the international literature review provided in Chapter 2 (see sections 2.3, 2.3.1 and 2.3.2). This will be used to make a comparison of approaches used internationally and those used in South Africa, therefore enabling identification of gaps in the approaches used in the country relative to international practice.

### 3.3.1 Introduction

There are diverse benefits of conducting regular studies to estimate traffic crash costs. Amongst others, crash cost estimates are used by the public sector at both macro and micro level for a number of purposes, such as decision-making, promotion and lobbying or campaigns, amongst others (Schutte, Page & Dehlen, 1999:2.1). Knowledge of the cost of road crashes (in terms of loss of life, injuries, vehicle damage, medical and legal costs) is essential if road authorities, planners, safety organisations and other bodies involved in the prevention of road crashes want to know which benefits will result from the application of scarce resources to build safer roads, the elimination of ‘black spots’, the raising of maintenance standards, education and training of road users, and the enforcement of road safety measures (Verburgh et al., 1985:3). Furthermore, resources for road safety countermeasures are limited, and in the absence of crash costs, it would clearly be difficult to make an objective assessment of proposed projects (Cillié & Freeman, 1977:1) for resource allocation. Labuschagne (2016:14–15), TRL (1995:1), Bhala (2013:9), Svensson (2009:431), Mohamed (2015:43), Abelson (2008:2), Ismail and Abdelmageed (2010:220), Reddy, Negandhi, Singh and Singh (2009:550), García-Altés and Pérez (2006:65), Tooth (2010:7), SWOV (2012:1), Schutte et al. (1999:2.1) and Cillié (1975) particularly identify the following uses:

- **policy formulation** – placing the overall road safety problem in perspective;
- specific road **infrastructure decision-making**, for example road investment (provision of rehabilitation) and crash spot improvements, amongst others;
- road **operations decision-making**, for instance enforcement prioritisation, evaluation, optimisation and selection of road safety countermeasures;
- road **system management**, for example road pricing and cost recovery from users, allocation of financial and human resources;
- **setting of standards** in terms of road design, road object standards and vehicle safety;
- **benchmarking** – benchmarking road safety performance in comparison to other countries;
- **economic evaluation** – economic valuation of interventions aimed at reducing road traffic crashes, which then serves as a basis for the prioritisation of road safety improvement programmes and projects;
- **setting of road traffic regulations** with regard to speed limits, vehicle weight and dimension limits; and

- **monitoring and regulation** of road transport agencies.

Crash cost data are also used as input for economic analyses, such as CBAs (Abelson, 2008:2; Bhala, 2013:9; Cillié, 1975; García-Altés & Pérez, 2007:65; SWOV, 2012:1; Ismail & Abdelmageed, 2010:220; Labuschagne, 2016:15; Mohamed, 2015:43; Reddy et al., 2009:550; Schutte et al., 1999:2.1; Svensson, 2006:2; Tooth, 2010:7; TRL, 1995:1). The private sector and individuals use crash cost information for example for purposes of insurance and compensation claims (Schutte et al., 1999:2.1–2.2). Furthermore, CBA allows for quantifying the level of prevention (lives saved) compared to the monetary return on investment (ROI). By focusing investment on proven countermeasures, it is possible to demonstrate measurable results and show a meaningful return on these investments.

It is against this background that through the CSIR, the DoT conducted numerous crash cost assessment studies starting from 1965 using 1962 as a base year (see Table 1.1). It is evident from Table 1.1 that the HCA was used in all the previous studies that the CSIR conducted in South Africa. Furthermore, in order to include a cost component that serves as a proxy for loss of quality of life costs, studies by Morden (1989), De Haan (1992), Schutte (2000), De Beer and Van Niekerk (2004) as well as by Labuschagne (2016) included the pain, grief and suffering cost component (see Table 1.1). The key findings of the studies in Table 1.1 are amongst others as follows:

- The 1965 study estimated the 1962 and 1963 cost of road traffic crashes at R48 339 121 and R49 915 260 per annum respectively (Burton & Eksteen, 1967; De Vos & Burton, 1965:12).
- The 1972, 1975, 1980, 1984, 1986, 1988 and 1991 costs of road traffic crashes were estimated at R325 030 000; R610 924 700; R1 261 381 788; R2 478 095 983; R4 134 108 869; R4 991 022 642 and R6 147 167 693 respectively (Cillié, 1975:3; Cillié & Freeman, 1977:23; De Haan, 1992:6-2; Glass & Hamilton, 1987:42; Goosen & Kolman, 1982:43; Morden, 1989:37; Verburgh et al., 1985:43).
- Labuschagne (2016:iii) estimated the 2015 cost of road traffic crashes at R142 951 000 000.

The cost estimates for each of the years referred to above show that the costs of road traffic crashes are increasing exponentially thus making a case for a need for interventions to arrest this challenge. Furthermore, it is also clear from Table 3.6 that prior to the study by Labuschagne (2016), South Africa last conducted crash cost assessment studies more than a decade before that in 2004. This means that crash cost estimates determined through the last study conducted in 2004 were outdated and thus could not be relied upon for road safety policymaking and resource allocation. Furthermore, all the studies conducted in South Africa, including the study by Labuschagne in 2016, used the HCA despite newer international literature advocating for the use of the WtPA (Andersson & Treich, 2011:3; Cawley, 2006:5–6; O'Reilly et al., 1994:45).

It is therefore critical for South Africa to update crash cost estimates using the latest available crash data. Literature recommends (see Labuschagne, 2016, 2011; Wijnen, et al, 2017) that in order to establish whether approaches used in previous studies are still relevant for use in this research, it is also critical to review approaches used in previous studies. The intention was to compare these with approaches currently used internationally. The review of previous studies also helped to identify gaps in approaches that were used in previous SA crash costing studies compared to those used by countries that had proved over the years to be pioneers in the assessment of road crash costs as well as road safety performance. Only reports that were obtained directly from the CSIR were considered for the review of literature on the approaches and methodologies used in previous SA studies because the institution is the custodian of all road crash cost assessment studies commissioned by the DoT in South Africa. These reports were therefore officially approved by the DoT.

This section consequently provides a review of the HCA cost components and a comparison of estimates of previous crash cost valuation studies conducted in South Africa.

The cost components considered in the application of the HCA used in all twelve studies conducted in South Africa are discussed in section 3.3.2.

### 3.3.2 Cost components used in previous studies

The fourth secondary objective of this study aimed at structuring the components of and the relationship between the HCA and the WtPA (see section 1.3.2). It was therefore critical to ensure that the structuring of these components also considered the SA perspective, particularly in terms of the components that previous SA studies took into account in the assessment of road traffic crash costs.

The studies by Cillié and Freeman (1977:6) and Goosen and Kolman (1982:4) considered the following cost categories, disaggregated first into measurable and non-measurable costs. The measurable and non-measurable cost components are what the Victoria Transport Policy Institute referred to as 'market and non-market cost components' (see Table 2.2) (Victoria Transport Policy Institute, 2013).

**Table 3.6: Classification of cost components used in road crash costing**

| Measurable costs | Non-measurable costs |
| --- | --- |
| *Variable costs:*<br>• Loss of output<br>• Property damage costs<br>• Medical costs<br>• Administrative costs<br>• Legal costs<br>• Loss of time<br>• Miscellaneous incidental costs, e.g. telephone calls, telegrams, flowers, travelling expenses, towing costs, and hiring of domestic help. | • The value of human life<br>• Loss of life's amenities<br>• Physical and mental suffering, i.e. pain, shock, anguish, horror, grief and fear.<br>• Inconvenience and disruption<br>• Other intangible costs such as anxiety, tension, frustration, loneliness, fatigue and nervousness. |
| *Fixed costs:*<br>• Non-variable administrative costs<br>• Road safety research and promotion<br>• Processing and publishing of road crash data<br>• Road improvements directly related to safety<br>• Road safety policing and enforcement<br>• Other fixed costs | |

*Source: Adapted from Cillié and Freeman (1977:6) and Goosen and Kolman (1982:4).*

As it is evident in Table 3.6, measurable costs are further divided into variable costs and fixed costs. Variable costs are costs that vary in proportion to variation in road traffic crash volumes (Cillié & Freeman, 1977; Goosen & Kolman, 1982). However, fixed costs do not vary irrespective of road traffic volumes (Cillié & Freeman, 1977; Goosen & Kolman, 1982). Non-measurable costs are non-market costs to which no rand value can be attached as it involves the value of human life and loss of the quality and amenities of life.

Despite the many categories and components cited by Cillié and Freeman (1977:6) as well as Goosen and Kolman (1982:4) in Table 3.6, the majority of previous SA studies only considered measurable crash costs and variable costs. However, as approaches used in estimating the cost of road traffic crashes in South Africa evolved in line with international practice, some elements of fixed costs and non-measurable costs started to be considered.

The studies conducted in SA as listed in Table 1.1 considered common cost components. However, each of them introduced new cost components as well. Therefore, in order to establish which components were considered in each of the previous road traffic crash cost assessment studies in Table 1.1, the sub-sections below compare cost components used in each of these studies. The cost components are summarised in Figure 3.2.

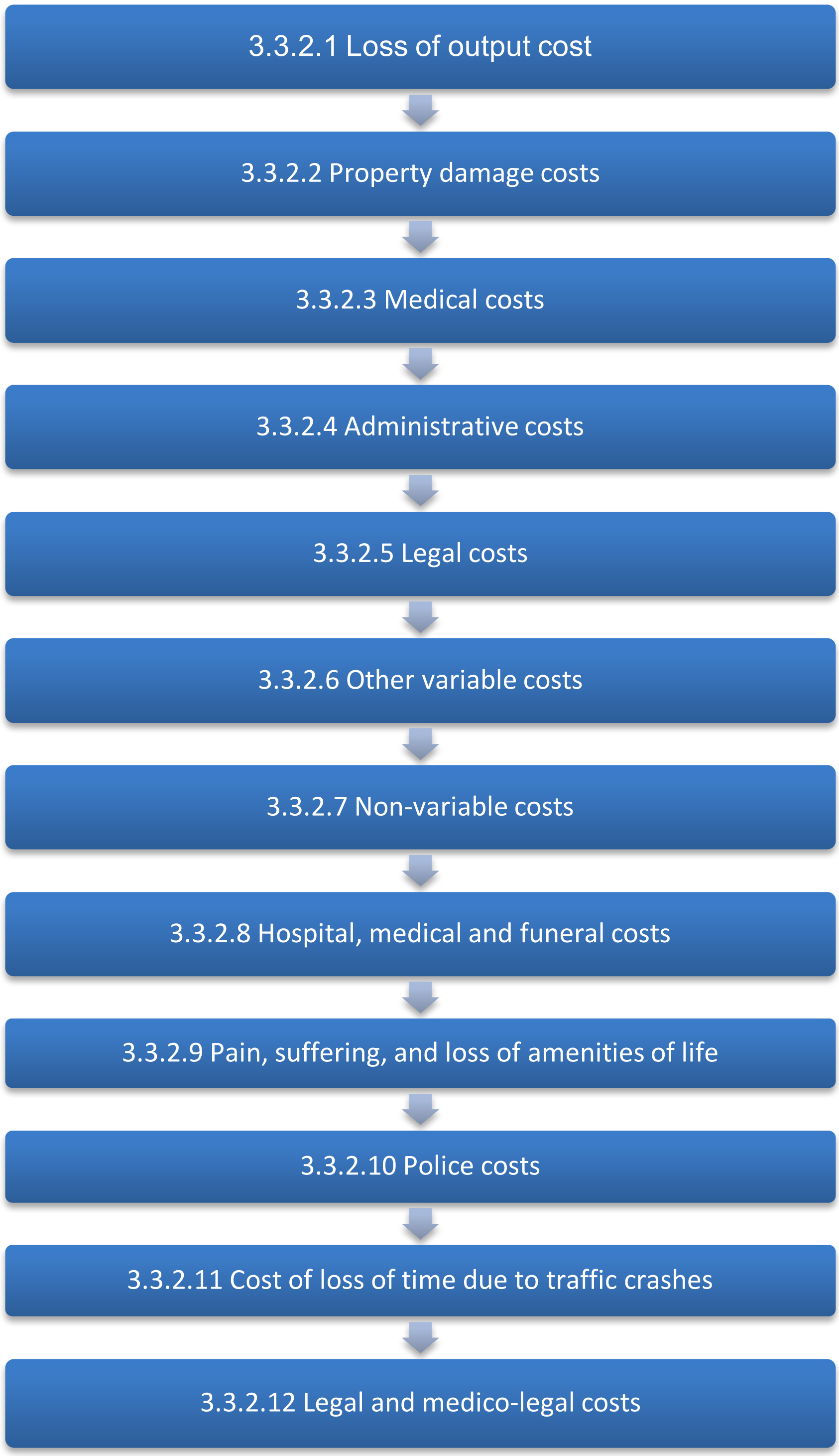


**Figure 3.2: Cost components considered by the CSIR in previous road traffic crash cost assessment studies: 1965–2016**

Each one of the cost components in Figure 3.2 are discussed below.

### *3.3.2.1 Loss of output cost*

When a working person is killed in a road traffic crash, the community loses his or her production for what would have been the remainder of his or her working life (Cillié, 1975:7; Cillié & Freeman, 1977:12; Wijnen et al., 2016:9). Therefore, loss of output due to fatalities (premature death) is defined as the output that would have been produced over the remainder of the economic life of those people killed in road crashes (Schutte, 2000:4–3; Wijnen et al., 2016:10). Furthermore, when an employed person is unable to work because of a car crash injury, the community loses his or her production for the duration of his or her incapacity (Cillié, 1975:8; Goosen & Kolman, 1982:14; Wijnen et al., 2016:10). Cillié (1975:8) as well as Goosen and Kolman (1982:16) further indicate that most output in an economy is paid for directly in the form of monetary remuneration via the market mechanism; however, some output is provided without direct payment. The principal example of this kind of output is the services provided by housewives. These services constitute a major portion of the contribution of women to the community and are an important part of the real welfare of society. Any loss of such services – whether temporary or permanent – is therefore a real loss to the community. Contrary to the Australian study which considered 3% and alternative discount rates of 2% and 5% (BITRE, 2009:91), where discounting the future values was required in South African studies, Cillié and Freeman (1977:13), Goosen and Kolman (1982:18) and Verburgh et al. (1985:15) as well as Schutte (2000:4-4) used a rate of 8% per annum. While Goosen and Kolman indicated that there is no correct rate and the selection of 8% is arbitrary to some extent, Verburgh et al. (1985:15) comment that a rate of 8% was chosen in their case because it was felt that a significantly lower rate would overstate the relative importance of future costs, whereas a higher rate would be impractical because of the long periods over which the discounting is effected in some cases. They further indicate that even although this view fails to suggest any precise means of determining an economically accurate discount rate, this is a general view with which it is hard to disagree (Verburgh et al., 1985:15).

Table 3.7 indicates SA studies that considered the loss of output cost component in the assessment of the cost of road traffic crashes.

**Table 3.7: Loss of output cost**

| | Author and study publication year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Cost component** | **Cillié (1975)** | **Cillié & Freeman (1977[9])** | **Goosen & Kolman (1982[10])** | **Verburgh et al. (1985)** | **Glass & Hamilton (1987)** | **Morden (1989)** | **Schutte (2000)** | **Labuschagne (2016)** |
| Loss of output | √ | √ | √ | √ | √ | √ | √ | √ |
| Death | √ | √ | √ | √ | √ | √ | √ | √ |
| Serious injury | √ | √ | √ | √ | √ | √ | √ | √ |
| Slight injuries | √ | √ | √ | √ | √ | √ | √ | √ |
| Unpaid services (e.g. those of housewives) | √ | X | X | X | X | X | X | X |

Note: √ = Cost component was used in the study and **X** =Cost component was not used in the study

It is evident from Table 3.7, that all the studies considered loss of output due to death, serious injuries as well as slight injuries in their estimation of loss of output costs. Unpaid services, such as those of housewives, amongst others, were only considered by Cillié (1975:8–9) in the estimation of the cost of 1972 road crashes. Therefore, costs resulting from the three injury severity levels, namely death, serious injury and slight injury should be the only variables to be considered in future studies.

### *3.3.2.2 Property damage costs*

More than 50% of the total cost to the national economy is in the form of property damage cost (Schutte, 2000:4-4). Property or material damage caused by road crashes comprises:

- damage to vehicles;
- damage to objects inside vehicles and the personal effects of casualties and occupants (such as vehicle cargoes or freight, clothing, spectacles and wristwatches); and
- damage to objects outside vehicles, whether fixed or moveable (roadside objects, fixed property) (Cillié, 1975:31; Cillié & Freeman, 1977:14; Glass & Hamilton, 1987:18; Goosen & Kolman, 1982:21; Schutte, 2000:4-4; Verburgh et al., 1985:19; Wijnen et al., 2016:10).

[9] This study also included projections of crash costs for two subsequent years, namely 1976 and 1977.

[10] The study did not consider medical costs of fatalities, funeral costs policing costs and time costs (Goosen & Kolman, 1982:21–22).

Table 3.8 summarises previous SA studies that took the cost of property damage into consideration as a cost component in their valuation of road traffic crash costs. The table further indicates which of the different property types, such as vehicles, road infrastructure and vehicle freight, were considered by each one of the eight studies.

**Table 3.8: Costs of property damage**

| | Author and study publication year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Cost component** | **Cillié (1975)** | **Cillié & Freeman (1977)[11]** | **Goosen & Kolman (1982)** | **Verburgh et al. (1985)** | **Glass & Hamilton (1987)** | **Morden (1989)** | **Schutte (2000)** | **Labuschagne (2016)** |
| Costs of property damage | √ | √ | √ | √ | √ | √ | √ | √ |
| Damage to vehicles | √ | √ | √ | √ | √ | √ | √ | √ |
| Damage to vehicle by type of vehicle | X | X | X | √ | X | √ | X | X |
| Damage to vehicle by degree of severity | √ | √ | √ | √ | X | √ | √ | X |
| The severity of the crash with regard to person injury | X | X | X | X | √ | X | √ | X |
| Type of accident (with head-on crashes incurring the greatest vehicle damage) | X | X | X | X | √ | X | X | X |
| Place of crash (rural vs. urban) | X | X | X | X | √ | X | X | X |
| [12]Other property damage costs: | √ | √ | √ | √ | X | √ | X | √ |
| Damage to objects inside vehicles and the personal effects of casualties and occupants (such as vehicle cargoes, clothing, spectacles and wristwatches | √ | √ | √ | √ | X | √ | X | √ |
| Damage to objects outside vehicles, whether fixed or movable (such as roadside objects or fixed property). | √ | √ | √ | √ | X | √ | X | √ |

Note: √ = Cost component was used in the study and **X** =Cost component was not used in the study

Table 3.8 indicates that all the studies conducted in South Africa considered property damage costs in the assessment of the costs of road traffic crashes. However, different studies considered different sub-components of the cost of the property damage component. Noteworthy is the observation that only Verburgh et al. (1985:20–21) and Morden (1989:13) included damage to vehicle by type of vehicle. Damage to vehicle is divided into four levels of damage severity: fatal, serious, slight and damage only (Glass & Hamilton, 1987:21; Goosen & Kolman, 1982:22; Schutte, 2000:5-2). Glass and Hamilton (1987:19) also divide vehicles into two vehicle classes, namely motor cars and heavy-duty vehicles. They however

[11] This study also took into account projections of crash costs for two subsequent years, namely 1976 and 1977.

[12] Costs of damage of objects inside and outside vehicles were estimated as a single figure.

do not consider damage to objects inside and outside the vehicle arguing that damage sustained by objects inside and outside the vehicle is of little significance to the total cost of road crashes (Glass & Hamilton, 1987:22). Schutte (2000:4-4) also omitted these two categories indicating that there was no reliable information available on them. However, the most recent study only considered vehicle damage, damage to objects inside the vehicle and objects outside vehicles as sub-components of property damage costs (Labuschagne, 2016:30).

#### *3.3.2.3 Medical costs*

Medical costs arising from road crashes obviously only result from injury crashes, i.e. a crash in which there is at least one casualty, whether slight, serious or fatal (Cillié, 1975:37; Cillié & Freeman, 1977:15; Goosen & Kolman, 1982:26; Verburgh et al., 1985:22). These are costs of medical treatment at the scene of the crash or in private or public hospitals (Labuschagne, 2016:29; Wijnen et al., 2016:10). These mainly comprise four cost types, namely:

- the cost of treatment by professional medical and para-medical practitioners such as doctors, dentists, surgeons, anaesthetists, osteopaths, nurses, physiotherapists, occupational therapists;
- the fees charged by hospitals and nursing homes, both for in-patients and out-patients, for hospitalisation and ancillary services;
- the cost of supplies and medications purchased by crash victims whether on prescription or not; and
- ambulance costs (Cillié, 1975:37; Cillié & Freeman, 1977:15; Goosen & Kolman, 1982:26; Labuschagne, 2016:29; Verburgh et al., 1985:22–23; Wijnen et al., 2016:10).

Ambulance costs broadly comprise all costs imposed by the transport of crash victims, whether by ambulance or not (Cillié & Freeman, 1977:15). Unlike Cillié and Freeman (1977:15), Cillié (1975:37) and Verburgh et al. (1985:23) do not treat funeral costs as medical costs; however, they include them as a separate item under medical costs of fatalities. Funeral costs are inescapable insofar as every person must die sooner or later – the crash merely advances the cost from some future date to the present. The amount chargeable as a road crash cost is thus only the difference between the present values of the two costs (Cillié & Freeman, 1977:15).

Table 3.9 shows SA road traffic crash cost assessment studies that included medical cost components as well as the different sub-components that constitute the overall medical costs.

**Table 3.9: Medical costs**

| Cost component | Cillié (1975) | Cillié & Freeman (1977)[13] | Goosen & Kolman (1982) | Verburgh et al. (1985) | Glass & Hamilton (1987) | Morden (1989) | Schutte (2000) | Labuschagne (2016) |
|---|---|---|---|---|---|---|---|---|
| | Author and study publication year | | | | | | | |
| Medical costs | √ | √ | √ | √ | √ | X | X | √ |
| Ambulance costs | √ | √ | √ | √ | X | X | X | √ |
| Funeral costs | √ | √ | √ | √ | X | X | X | √ |
| All other medical costs | √ | √ | √ | √ | X | X | X | X |
| Medical costs for fatal injuries: | X | X | X | X | √ | X | X | X |
| *Helicopter* | X | X | X | X | √ | X | X | X |
| *Ambulance* | X | X | X | X | √ | X | X | X |
| *Intensive care* | X | X | X | X | √ | X | X | X |
| *X-rays* | X | X | X | X | √ | X | X | X |
| *Theatre* | X | X | X | X | √ | X | X | X |
| Medical costs for serious injuries | X | X | X | X | √ | X | X | X |
| *Helicopter* | X | X | X | X | √ | X | X | X |
| *Ambulance* | X | X | X | X | √ | X | X | X |
| *Intensive care* | X | X | X | X | √ | X | X | X |
| *X-rays* | X | X | X | X | √ | X | X | X |
| *Special care wards* | X | X | X | X | √ | X | X | X |
| *Normal wards* | X | X | X | X | √ | X | X | X |
| *Theatre* | X | X | X | X | √ | X | X | X |
| Medical costs for slight injuries | X | X | X | X | √ | X | X | X |
| *Ambulance* | X | X | X | X | √ | X | X | X |
| *X-rays* | X | X | X | X | √ | X | X | X |
| *Physiotherapy* | X | X | X | X | √ | X | X | X |
| *Normal wards* | X | X | X | X | √ | X | X | X |
| *Other medical*[14] | X | X | X | X | √ | X | X | X |

Note: √ = Cost component was used in the study and **X** =Cost component was not used in the study

As Table 3.9 shows, studies conducted by (Cillié, 1975), (Cillié & Freeman, 1977), (Goosen & Kolman, 1982), (Verburgh et al., 1985) and (Labuschagne, 2016) all considered ambulance costs, funeral costs and all other medical costs. However, Glass and Hamilton

[13] This study also included projections of crash costs for two subsequent years, namely 1976 and 1977.

[14] Including doctors, dentists and other specialists.

(1987:24–26) further categorise medical costs into medical costs for fatal injuries, medical costs for serious injuries and medical costs for slight injuries. The fact that there are no medical costs indicated for studies conducted by Morden (1989) and Schutte (2000) does not mean that these studies did not consider medical costs in their assessment of road crash costs; however, they used a slightly different name (hospital, medical and funeral costs), which also included other costs not included in the studies by (Cillié, 1975), (Cillié & Freeman, 1977), (Goosen & Kolman, 1982) and (Verburgh et al., 1985) studies. As a result, their medical costs have been discussed under a separate cost component.

#### *3.3.2.4 Administrative costs*

Administrative costs include costs of police, fire services and other emergency services (other than medical services) that assist at the scene of the crash (Wijnen et al., 2016:10). Furthermore, there are administrative costs related to insurances (vehicle, health and other insurances) (Wijnen et al., 2016:10). The same sub-components were considered for the SA road traffic crash cost assessment studies (Cillié, 1975:44–46; Cillié & Freeman, 1977:17; Glass & Hamilton, 1987:28–32; Goosen & Kolman, 1982:31–35; Labuschagne, 2016:31; Schutte, 2000:4–5; Verburgh et al., 1982:27). Administrative costs attributed to road crashes are considered to comprise two groups, namely costs incurred by the police in the investigation and recording of crashes, and the variable (or semi-variable) administrative costs of companies which transact motor vehicle insurance business (Cillié & Freeman, 1977:17; Glass & Hamilton, 1987:28–32; Labuschagne, 2016:31; Verburgh et al., 1982:27–29;). Variable costs in the case of insurance companies are costs that are to a large extent variables related to the number of claims handled. These include management expenses, commissions and assessor's fees, amongst others (Cillié & Freeman, 1977:17; Goosen & Kolman, 1982:36; Labuschagne, 2016:30).

Table 3.10 indicates the SA studies that considered administrative costs as a cost component in their valuation of road traffic crash costs together with sub-components that they regarded as constituting the overall administrative costs.

**Table 3.10: Administrative cost**

| Cost component | Author and study publication year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Cillié (1975)** | **Cillié & Freeman (1977)[15]** | **Goosen & Kolman (1982)** | **Verburgh et al. (1985)** | **Glass & Hamilton (1987)** | **Morden (1989)** | **Schutte (2000)** | **Labuschagne (2016)** |
| Administrative costs | √ | √ | √ | √ | √ | X | X | √ |
| Police[16] | √ | √ | √ | √ | √ | X | X | √ |
| On-scene crash investigation | √ | √ | X | √ | √ | X | X | √ |
| Investigation undertaken by the uniform investigation branch (UIB) | √ | √ | √ | √ | √ | X | X | √ |
| Insurance | √ | √ | √ | √ | √ | X | √ | √ |
| Management expenses | X | X | √ | √ | √ | X | X | √ |
| Commissions | √ | √ | √ | √ | √ | X | X | √ |
| Motor Vehicle Accident (MVA) fund administrative costs | X | X | X | X | X | √ | X | √ |
| Assessor's fee | √ | √ | X | X | X | √ | X | √ |
| Vehicle claims – administrative costs | X | X | X | X | X | √ | X | √ |

As it is evident from Table 3.10, studies by Labuschagne (2016), Cillié (1975), Cillié and Freeman (1977), Goosen and Kolman (1982), Verburgh et al. (1985) and Glass and Hamilton (1987) considered on-scene crash investigation and investigation undertaken by the UIB costs under 'police costs' (Glass & Hamilton, 1987:30; Labuschagne, 2016:31; Verburgh et al., 1985:28–29). Glass and Hamilton (1987:28) also specified management expenses and commissions under insurance costs. Morden (1989:31–32) introduced MVA

[15] This study also included projections of crash costs for two subsequent years, namely 1976 and 1977.

[16] These include costs for travelling to and from accidents, salaries for on-scene accident investigations, completing of accident report forms, travelling costs and uniformed branch investigation as well as salaries for uniformed branch investigation.

fund administrative costs, assessor's fees, and vehicle claims administrative costs under 'administrative costs'. Schutte (2000) treated the different items under 'administrative costs' as either separate items or as part of components that he added.

### *3.3.2.5 Legal costs*

Legal costs arising from road crashes are fully chargeable as variable crash costs and they are borne by insurance companies, vehicle owners or drivers, crash casualties or their dependants, and the State (Cillié, 1975:48; Cillié & Freeman, 1977:18; Goosen & Kolman, 1982:35; Verburgh et al., 1985:30). These costs are incurred, amongst others, when there is a legal dispute among crash participants regarding liability, when legal proceedings are instituted by the state against one or more of the participants, during the preparation of certain claims by policyholders or claimants, and during the investigation and settlement of certain claims by insurance companies (Cillié, 1975:48; Cillié & Freeman, 1977:18; Goosen & Kolman, 1982:35; Schutte, 2000:4–5; Verburgh et al., 1985:30).

Table 3.11 provides details in terms of the studies that included legal costs as a cost component in the assessment of the cost of road crashes. It also identifies sub-components, which each of the studies included under legal costs.

**Table 3.11: Legal costs**

| | Author and study publication year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Cost component** | **Cillié (1975)** | **Cillié & Freeman (1977)[17]** | **Goosen & Kolman (1982[18])** | **Verburgh et al. (1985)** | **Glass & Hamilton (1987)** | **Morden (1989)** | **Schutte (2000)** | **Labuschagne (2016)** |
| Legal costs | √ | √ | √ | √ | √ | X | √ | √ |
| Legal proceedings by state | X | X | √ | √ | √ | X | X | √ |
| Not resulting in court hearings | √ | √ | √ | √ | √ | X | X | √ |
| Resulting in court hearings | √ | √ | √ | √ | √ | X | X | √ |
| Civil legal proceedings | X | X | √ | √ | √ | X | X | √ |
| Not resulting in court hearings | X | X | √ | √ | √ | X | X | √ |
| Resulting in court hearings | X | X | √ | √ | √ | X | X | √ |

[17] This study also included projections of crash costs for two subsequent years, namely 1976 and 1977.

[18] Instead of legal proceedings by the state, this study estimated legal costs per involvement (Goosen & Kolman, 1982:35–36).

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Legal costs of claimants | X | X | X | √ | X | X | X | √ |
| MVA third-party injury | X | X | X | √ | X | X | X | √ |
| Comprehensive cover and balance of third party | X | X | X | √ | X | X | X | √ |
| Legal costs paid out in the motor vehicle claims | X | X | X | X | X | X | √ | √ |
| Legal costs paid out to the injured person(s) by the RAF | X | X | X | X | X | X | √ | √ |
| Costs involved for the medico-legal report requested by the RAF | X | X | X | X | X | X | √ | √ |

As it is evident from Table 3.11, studies conducted in 1975, 1977, 1982 and 2016 group legal costs into two categories, namely those not resulting in court hearings, and those resulting in court hearings.

However, Verburgh et al. (1985:37) as well as Glass and Hamilton (1987:33–36) further disaggregated legal costs into those resulting from legal proceedings by the state, civil legal proceedings and legal costs of claimants. They further divided the first two costs into proceedings not resulting in court hearings and those that result in court hearings. Legal costs of claims comprise costs resulting from MVA third-part injury and comprehensive cover and balance of third-party claims. Labuschagne (2016:30) and Schutte (2000:4–5) identified three categories of legal costs:

- legal costs paid out in the motor vehicle claims;
- legal costs paid out to the injured person by the RAF; and
- costs related to the medico-legal report requested by the RAF.

#### *3.3.2.6 Other variable costs*

Other variable costs comprise –

- loss of time (due to recording the crash, filling out a claim form, taking the car to the assessor, taking it to and collecting it from panel beaters, engaging other people to provide alternative transport means, taking injured persons to hospital, fetching people from hospital and/or making funeral arrangements; and
- miscellaneous incidental expenses, such as telephone calls, telegrams, flowers and vehicle towing expenses (Cillié & Freeman, 1977:19; Goosen & Kolman, 1982:40; Labuschagne, 2016:30;). This component was introduced for the first time by Cillié and Freeman (1977:19–20) in an attempt to enhance completeness of cost estimates.

Table 3.12 shows SA studies that considered the cost component 'other variable costs' in the assessment of road traffic crash costs.

**Table 3.12: Other variable costs**

| | Author and study publication year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Cost component** | **Cillié (1975)** | **Cillié & Freeman (1977)**[19] | **Goosen & Kolman (1982)** | **Verburgh et al. (1985)** | **Glass & Hamilton (1987)** | **Morden (1989)** | **Schutte (2000)** | **Labuschagne (2016)** |
| Other variable costs[20] | X | √ | √ | √ | X | X | X | X |
| Loss of time[21] | X | √ | √ | √ | √ | X | √ | √ |
| Miscellaneous incidental expenses | X | √ | √ | √ | √ | X | √ | X |
| Telephone calls | X | √ | √ | X | √ | X | √ | X |
| Telegrams | X | √ | √ | X | √ | X | X | X |
| Flowers | X | √ | √ | X | √ | X | √ | X |
| Vehicle towing expenses | X | √ | √ | X | √ | X | √ | √ |
| Vehicle driving expenses (i.e. Vehicle hire expenses) | X | X | X | √ | X | X | X | X |
| Printed material | X | X | X | √ | √ | X | √ | X |
| Crash prevention and data collection costs | X | X | X | X | √ | X | X | √ |

As it is evident from Table 3.12, studies that also included other variable costs are those conducted in 1985 and 1987 (Glass & Hamilton, 1987:38; Verburgh et al., 1985:37–39). In addition to those costs included by Cillié and Freeman (1977:19) as well as Goosen and Kolman (1982:40), Glass and Hamilton (1987:38) only added printed material. Glass and Hamilton (1987:39) also included 'crash prevention' and 'data collection costs' as sub-components of miscellaneous costs. Schutte (2000:4–6) briefly identifies the following components as comprising miscellaneous costs:

- loss of time, which results from a number of reasons, for instance completing forms, visiting insurance companies and workshops, visiting family and friends in hospital and attending funerals;

[19] This study also included projections of crash costs for two subsequent years, namely 1976 and 1977.

[20] Estimates vary depending on casualty crash type, i.e. whether the crash is fatal, serious, slight or damage only.

[21] Glass and Hamilton (1987:37) and Schutte (2000:4–6) had loss of time under the component 'miscellaneous costs'.

- towing costs; and
- other, e.g. flowers, cards and telephone calls.

Labuschagne (2016:30–31) only refers to road traffic crash reporting, data capturing and analysis as well as towing services costs and time delay or loss of time to which he adds excess fuel consumption and emissions due to congestion.

The exclusion of the sub-components under variable costs by Morden (1989) can be ascribed to the fact that he included these under a separate component or he completely treated them as components on their own.

#### *3.3.2.7 Non-variable costs*

Some of the fixed costs that fall under this component are very debatable as to whether or not they are strictly crash costs (Cillié & Freeman, 1977:21). For instance, it is not clear whether the cost of road policing and enforcement is chargeable in part to road crashes, and if so, to what extent (Goosen & Kolman, 1982:41). It can be argued on the one hand that the cost is incurred to promote the smooth functioning of the road transport system in general and that it is not related to road crashes, but on the other hand, it is likely that road policing costs are influenced to some degree by crash occurrence (Cillié & Freeman, 1977:21; Goosen & Kolman, 1982:41).

Aspects considered as part of non-variable costs are summarised in Table 3.13.

**Table 3.13: Non-variable costs**

| Cost component | Author and study publication year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Cillié (1975) | Cillié & Freeman (1977)[22] | Goosen & Kolman (1982) | Verburgh et al. (1985) | Glass & Hamilton (1987) | Morden (1989) | Schutte (2000) | Labuschagne (2016) |
| None-variable crash costs | √ | √ | √ | X | X | X | X | X |
| Administrative costs[23] | √ | √ | √ | X | X | X | X | X |
| (Road safety) research and promotion costs[24] | √ | √ | √ | √ | √ | X | X | X |
| Cost of processing and publishing road traffic crash data | X | X | X | √ | √ | X | X | √ |
| Accident prevention and data collection costs (National Road Safety Council (NRSC), Safety Branch – National Initiative for Transport and Road Safety Research (NITRR) and Central Statistics Services (CSS) now called Statistics South Africa (Stats SA) | X | X | X | X | √ | X | X | √ |

As Table 3.13 shows, in order to avoid complex theoretical arguments and also because fixed crash costs are very minor compared to variable costs (and in any event, difficult to measure in most cases), the studies by (Cillié, 1975), (Cillié & Freeman, 1977) and (Goosen & Kolman, 1982) only considered two items, namely non-variable administrative costs and the cost of road safety research and promotion. Verburgh et al. (1985:39–40) treat road safety research and promotion costs as well as cost of processing and publishing road crash statistics as separate components. Labuschagne (2016:31) only considers road traffic crash reporting, data capturing and analysis.

[22] This study also included projections of crash costs for two subsequent years, namely 1976 and 1977.

[23] Cost of processing and publishing road crash statistics (Glass & Hamilton, 1989), cost of road policing and traffic control, costs incurred by motor vehicle manufacturers in designing vehicles to higher safety standards, and costs incurred by roads authorities in designing and constructing safer roads (Glass & Hamilton, 1989).

[24] Figures obtained from the NRSC and the National Initiative for Transport and Road Research (Safety Branch), CSIR (Cillié, 1975; Cillié & Freeman, 1977; Glass & Hamilton, 1989; Goosen & Kolman, 1982; Verburg et al., 1985).

### *3.3.2.8 Hospital, medical and funeral costs*

Morden (1989:27–28) and Schutte (2000:4–5) described medical costs differently, namely hospital, medical and funeral costs (see Table 36). However, Labuschagne (2016:29) refers to this cost component as 'medical and funeral costs' which comprises funeral costs, medical treatment costs as well as rehabilitation costs. Cost of medical treatment entails treatment on scene or in a private or a public hospital, either uncompensated or compensated by medical aid or the RAF (Labuschagne, 2016:29). Whereas hospital and medical costs are self-explanatory, funeral costs are defined as the difference between the current cost of a funeral and the discounted cost of a funeral at the 'normal' time of death (Schutte, 2000:4–5).

Table 3.14 shows which of the eight road traffic crash cost assessment studies included hospital, medical and funeral costs as a cost component.

**Table 3.14: Hospital, medical and funeral costs**

| | Author and study publication year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Cost component** | **Cillié (1975)** | **Cillié & Freeman (1977)**[25] | **Goosen & Kolman (1982)** | **Verburgh et al. (1985)** | **Glass & Hamilton (1987)** | **Morden (1989)** | **Schutte (2000)** | **Labuschagne (2016)** |
| Hospital, medical and funeral costs | X | X | X | X | X | √ | √ | √ |

It is clear from Table 3.14, that the hospital, medical and funeral cost component was introduced into SA studies since 1989.

### *3.3.2.9 Pain, suffering and loss of amenities of life*

Many people injured in road traffic crashes suffer severe and prolonged pain, suffering and loss of amenities of life (Morden, 1989:24). However, although this component is important, there is little or no information available to quantify it, and it also excludes the costs suffered by the family of the victim (Schutte, 2000:4–5). Morden (1989:24) first introduced pain, suffering and loss of amenities of life as a cost component, and Schutte (2000:4–5) and Labuschagne (2016:35) continued to include this item as a cost component in subsequent studies (see Table 3.15).

[25] This study also included projections of crash costs for two subsequent years, namely 1976 and 1977.

**Table 3.15: Pain, suffering and loss of amenities of life**

| Cost component | Cillié (1975) | Cillié & Freeman (1977)[26] | Goosen & Kolman (1982) | Verburgh et al. (1985) | Glass & Hamilton (1987) | Morden (1989) | Schutte (2000) | Labuschagne (2016) |
|---|---|---|---|---|---|---|---|---|
| | Author and study publication year | | | | | | | |
| Pain, suffering, and loss of amenities of life | X | X | X | X | X | √ | √ | √ |

Labuschagne (2016:29) and Morden (1989:24) further assert that, if an injured person's quality of life is reduced as a direct result of a crash, they are rightfully entitled to some measure of compensation. Compensation is awarded with respect to:

- medical and hospital expenses;
- loss of income;
- general damages, such as:
  - scarring; and
  - pain and suffering; and
- a proportion of the legal and medico-legal costs to finalise the claim (Labuschagne, 2016:29; Morden, 1989:25).

#### *3.3.2.10 Police costs*

Labuschagne (2016:31) includes police costs under 'incident costs' and particularly focused on road traffic investigation and reconstruction as well as road traffic crash scene attendance and clean-up without specifically referring to them as 'police costs'. As Table 3.16 shows, Morden (1989:33) recognises policing costs as a separate road crash cost component.

Table 3.16 shows studies that explicitly include police costs as a cost component in their assessment of road traffic crash costs. It is clear from Table 3.16 that only one study, namely that by Morden (1989) specifically refers to this cost component as 'police costs'. The other, such as Labuschagne's study, identified two activities that are actually carried out by the police under 'incident costs', namely road traffic crash scene attendance and clean-up as well as road traffic crash investigation and reconstruction (Labuschagne, 2016:31).

[26] This study also included projections of crash costs for two subsequent years, namely 1976 and 1977.

**Table 3.16: Police costs**

| Cost component | Cillié (1975) | Cillié & Freeman (1977)[27] | Goosen & Kolman (1982) | Verburgh et al. (1985) | Glass & Hamilton (1987) | Morden (1989) | Schutte (2000) | Labuschagne (2016) |
|---|---|---|---|---|---|---|---|---|
| | Author and study publication year | | | | | | | |
| Police | X | X | X | X | X | √ | X | X |

The earlier studies included police costs as a sub-component of the administrative cost component. Therefore, even though Labuschagne (2016:35) does not specifically refer to this as 'police costs', it can be inferred that this cost component was included under 'incident costs' as traffic crash scene attendance and clean-up as well as road traffic crash investigation and reconstruction.

#### *3.3.2.11 Cost of time lost due to traffic crashes*

For every vehicle involved in a crash, at least one person will have to spend some time making arrangements to repair or replace the vehicle, to submit claim forms, and/or to attend to other incidental activities related to the crash. For this reason, Morden (1989:34) introduced 'loss of time' as a separate component of crash cost estimates (see Table 3.117).

Table 3.17 shows studies that included cost of lost time due to traffic crashes as a cost component in their assessment of the cost of road traffic crashes. Evidently, it is only Morden (1989:34) who included this cost component.

**Table 3.17: Cost of loss of time due to traffic crashes**

| Cost component | Cillié (1975) | Cillié & Freeman (1977)[28] | Goosen & Kolman (1982) | Verburgh et al. (1985) | Glass & Hamilton (1987) | Morden (1989) | Schutte (2000) | Labuschagne (2016) |
|---|---|---|---|---|---|---|---|---|
| | Author and study publication year | | | | | | | |
| Cost of loss of time due to traffic crashes | X | X | X | X | X | √ | X | X |

[27] This study also included projections of crash costs for two subsequent years, namely 1976 and 1977.

[28] This study also included projections of crash costs for two subsequent years, namely 1976 and 1977.

However, the seven other studies did not include this cost component. Therefore, there is no need to include this cost component in future studies given that even the international studies reviewed in Chapter 2 did not include it as well (see sections 2.3.1.1 to 2.3.1.5).

#### *3.3.2.12 Legal and medico-legal costs*

Where there is uncertainty regarding the seriousness of the injury sustained in a road traffic crash, insurance companies usually require a medico-legal report for claims from them (Morden, 1989:30). Morden (1989:28) consequently introduced legal and medico-legal costs as a crash cost estimate component as shown in Table 3.18.

**Table 3.18: Legal and medico-legal costs**

| | Author and study publication year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Cost component** | **Cillié (1975)** | **Cillié & Freeman (1977)[29]** | **Goosen & Kolman (1982)[30]** | **Verburgh et al. (1985)** | **Glass & Hamilton (1987)** | **Morden (1989)** | **Schutte (2000)** | **Labuschagne (2016)** |
| Legal and medico-legal costs | X | X | X | X | X | √ | X | X |

As Table 3.18 shows, only the study by Morden (1989) included legal and medico-legal costs as a cost component in their assessment of the cost of road traffic crashes in South Africa. The seven other studies did not consider this cost component.

### 3.3.3 Estimates of previous SA crash costing studies

All the road crash cost assessment studies conducted in South Africa found different road traffic crash cost estimates (Cillié, 1975; Cillié & Freeman, 1977; Glass & Hamilton, 1987; Goosen & Kolman, 1982; Labuschagne, 2016; Morden, 1989; Schutte, 2000; Verburgh et al., 1985). This could be attributed to the fact that even though the HCA was used in all the studies, in addition to variation in the number of victims, different or additional cost components were considered in the assessment of crash costs in the different studies. Improvement of the HCA results in addition or exclusion of cost components thus leading to an increase or decrease in cost estimates (Risbey et al., 2010:13).

Table 3.19 summarises cost components and total cost estimates of seven previous SA studies, the reports of which the CSIR could avail to the researcher (Cillié, 1975; Cillié & Freeman, 1977; Glass & Hamilton, 1987; Goosen & Kolman, 1982; Morden, 1989; Schutte, 2000; Verburgh et al., 1985).

Table 3.19 presents cost estimates per cost component for each one of the seven studies.

[29] This study also included projections of crash costs for two subsequent years, namely 1976 and 1977.

[30] Instead of legal proceedings by the state, this study estimated legal costs per involvement (Goosen & Kolman, 1982:35–36).

## Table 3.19: Comparison of cost components and total cost estimates of previous SA studies

| Cost component | Cost estimates | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cillié (1975) | Cillié & Freeman (1977)[31] | Goosen & Kolman (1982)[32] | Verburgh et al. (1985) | Glass & Hamilton (1987) | Morden (1989) | Schutte (2000) |
| Loss of output | 101 390 000 | 139 829 400 | 599 543 875 | 1 082 071 530 | 1 652 464 588 | 1 675 032 411 | 2 642 894 891 |
| Damage to property | 153 266 000 | 337 716 700 | 348 715 108 | 1 064 576 161 | 2 138 060 945 | – | 7 857 330 027[33] |
| Vehicles | – | – | – | – | – | 2 668 754 185 | – |
| Goods in transit | – | – | – | – | – | 79 862 400 | – |
| Pain, suffering and loss of amenities of life | – | – | – | – | – | 166 294 416 | 749 020 084 |
| Medical costs | 18 733 000 | 29 646 800 | 54 127 411 | 71 498 801 | 132 496 053 | – | – |
| Hospital, medical and funeral costs | – | – | – | – | – | – | 478 164 489 |
| Hospital | – | – | – | – | – | 61 420 863 | – |
| Medical | – | – | – | – | – | 126 748 797 | – |
| Funeral | – | – | – | – | – | 9 881 720 | – |
| Administrative costs | 25 775 000 | 29 978 100 | 102 908 248 | 164 120 116 | – | 119 013 356 | 604 594 157 |
| Legal costs | 25 866 000 | 39 654 000 | 68 177 880 | 52 130 430 | 67 482 580 | 42 849 432 | 354 237 390 |
| Insurance administrative costs | – | – | – | – | 135 201 888 | – | |
| Miscellaneous costs | – | – | – | – | 65 495 261 | – | 275 506 019[34] |
| Loss of time | – | – | – | – | – | 20 948 422 | – |
| Police | – | – | – | – | 12 618 554 | 20 216 640 | – |
| Other costs | – | 4 399 700 | 8 867 965 | 43 698 945 | – | – | – |
| Non-variable costs | – | – | 78 041 301 | – | – | – | – |
| **Total** | **325 030 000** | **581 224 700** | **1 261 381 788** | **2 478 095 983** | **4 203 819 869** | **4 991 022 642** | **12 961 747 057** |

[31] This study also included projections of crash costs for two subsequent years, namely 1976 and 1977.

[32] Instead of legal proceedings by the state, this study estimated legal costs per involvement (Goosen & Kolman, 1982:35–36).

[33] Schutte (2000) only considered vehicle damage as the only variable under ‘damage to property’.

[34] Schutte (2000) only considered time lost, towing cost and other (such as flowers, attending hospitals and funerals and completing forms).

It is evident from Table 3.19 that crash cost estimates significantly increased each year estimates were revised and, according to Risbey et al. (2010:13), these increases could be due to the following reasons:

- introduction of new cost components in the approach;
- more up-to-date crash data; as well as
- cost adjustments in line with the consumer price index (CPI).

It is for this reason that Labuschagne (2016) consequently found a total cost estimate of R142 951 000 000, which is 11 times higher than the 2000 cost estimate by Schutte (2000). Therefore, the inclusion of as many cost components as possible increases the accuracy of the cost estimates, while inclusion of few cost components results in underestimation of the overall cost of road traffic crashes.

All studies conducted in South Africa consistently considered loss of output, property damage, medical, legal and administrative costs in their assessment of road crash costs. However, Morden (1989:37) and Labuschagne (2016:35) respectively refer to vehicles and goods in transit cost and vehicle repair and infrastructure damage costs instead of property damage cost. Morden (1989:37) further splits medical cost into hospital, medical and funeral costs, while Schutte (2000:5-3) combined the three into one component namely medical and funeral costs. Glass and Hamilton (1987:42) split administrative cost into insurance administrative cost and police cost. Morden (1989:24), Schutte (2000:5-3) and Labuschagne (2016:35) introduced pain, suffering and loss of amenities of life as a new component, which most studies regarded as a 'controversial' intangible and unmeasurable cost. This cost component entails intangible losses, such as the quality of life a person would have enjoyed had he or she not died prematurely, including relatives and friends (BITRE, 2009:v).

## 3.4 CONCLUSION

The first secondary objective of this study (see 1.3.2) aimed at reviewing international literature on the assessment of road traffic crash costs. The literature review was intended to identify common components that are considered in the assessment of road crash costs in comparison to those used in the five countries considered in the international literature review in Chapter 2. In case there are cost components that were found to be used in the international literature but not used in SA studies, these could also be incorporated into the SA approach as well. Identification of these components will make it possible to achieve the fourth secondary objective of this study, namely structuring the components of, and relationship between, the HCA and the WtPA (see 1.3.2). In order to determine gaps within the approaches used in SA, it is necessary to review literature on the assessment of road traffic crash costs in SA as well. This chapter consequently reports on literature on previous road crash cost assessments in SA.

This chapter provided statistics on the state of road safety in South Africa as well as a review of literature on previous road traffic crash cost assessment studies conducted in the country. The literature review started with a comparison of cost components considered in each of the studies as well as the cost estimates calculated in each study. This literature review was intended to bring an SA perspective to secondary objectives 1 and 4 (see 1.3.2 for the secondary objectives).

The literature review reported in this chapter established that all previous road crash cost assessment studies conducted in South Africa considered loss of output cost, property damage cost, medical cost, legal cost and administrative cost. Another critical addition to this list is the pain, suffering and loss of amenities of life cost component, which was introduced by Morden (1989) and also included in subsequent studies by Schutte (2000) and Labuschagne (2016). These cost components are therefore added to those identified through a review of international literature and reported on in Chapter 2 and recommended for inclusion in this and future road crash cost assessment studies in South Africa. The current chapter therefore forms the foundation for the next chapter, Chapter 4, which synthesises the theory in Chapters 2 and 3 in order to come up with a hybrid framework for assessing road traffic crash costs in South Africa.

# CHAPTER 4:
# SELECTED APPROACHES AND METHODS TO ASSESS THE COSTS OF ROAD CRASHES IN SOUTH AFRICA

## 4.1 INTRODUCTION

The literature review introduced both international road traffic crash cost assessment studies (Chapter 2) and local studies (Chapter 3). The purpose of this literature review was twofold, namely to:

- achieve secondary objectives 1 (to provide a literature review on international best practice in the assessment of the cost of road traffic crashes) and 4 (to structure the components of, and the relationship between, the HCA and the WtPA) (see section 1.3.2); as well as to
- inform the execution of the empirical investigation of the WtPA in the SA context and updating the 2016 HCA-based SA crash cost estimates to determine the comparability of cost estimates of the two approaches thus directing the achievement of secondary objectives 2 (to investigate the WtPA empirically in the SA context) and 3 (to determine the comparability of the cost estimates of the HCA and the WtPA) respectively (see section 1.3.2 for details on the secondary objectives). It should be mentioned that this chapter explains how the selected approaches and methods were applied in this study as an illustration of how the approaches and methods could be applied in real road traffic crash assessment studies. Therefore, the cost estimates calculated in this study cannot be generalised for the South African population.

The purpose of this chapter is to reflect a comparison of the approaches used in the assessment of road crash cost studies in Australia, Belgium, Egypt, the Netherlands, Singapore, the United Kingdom and the United States of America, and those consistently used in the different studies conducted to estimate the crash costs in South Africa. The comparison culminated in recommendations on cost components that should be considered to improve the HCA part of the hybrid framework proposed in this study for use in future crash cost assessment studies in South Africa. The review also recommends the use of the WtPA for motor vehicle crash cost valuation. Therefore, this chapter will also present a discussion of how this approach was used and applied in this study. In particular, the chapter provides an overview of the cost components that are included in cost assessment studies according to international guidelines and international good practices, and compares these with those used in previous SA studies. The chapter attempts to make a contribution in terms of the approaches and methodology used in the assessment of road traffic crash costs in South Africa.

The layout and flow of Chapter 4 is depicted by Figure 4.1.

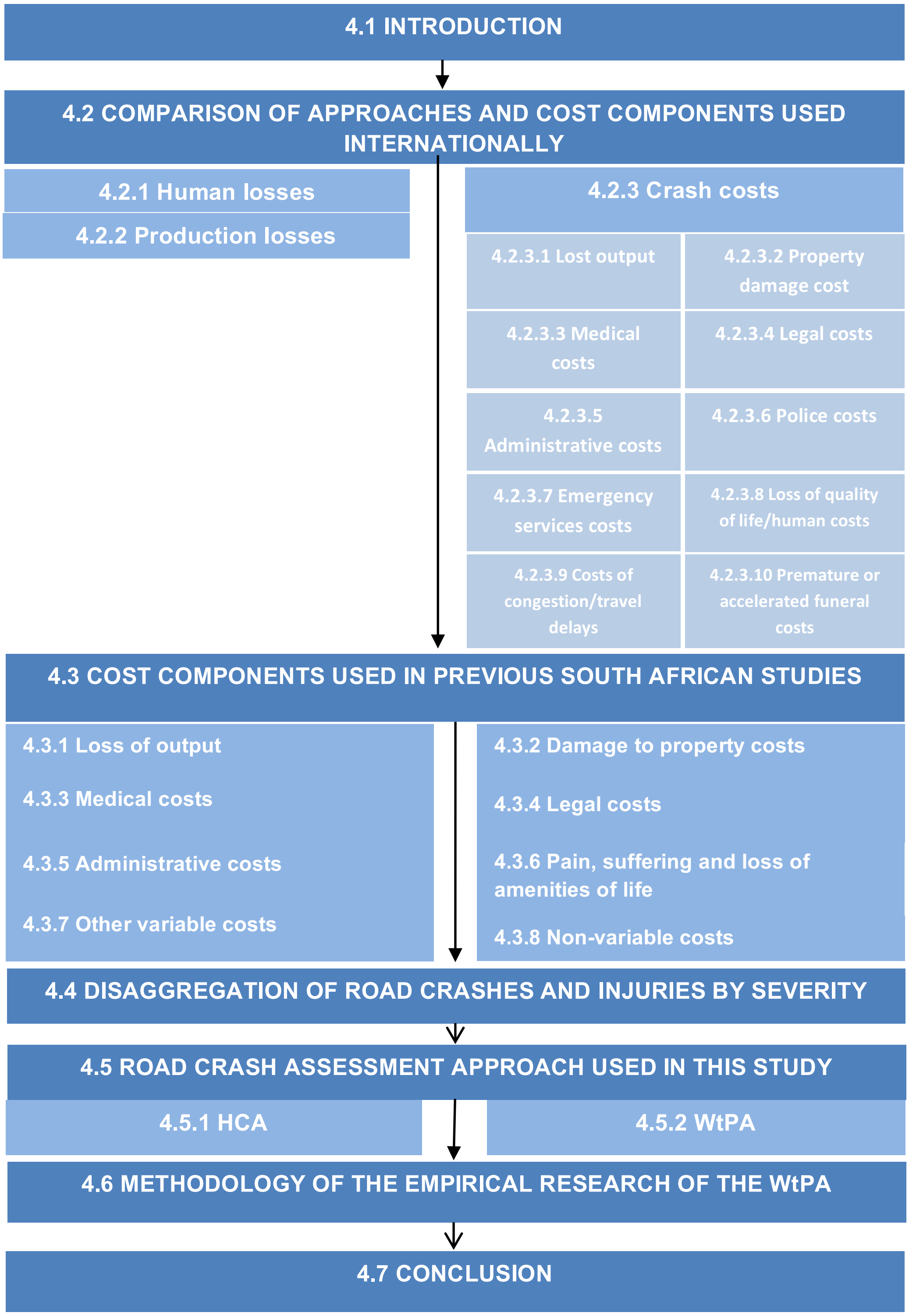


**Figure 4.1: Diagrammatic representation of Chapter 4**

Figure 4.1 provided a diagrammatic layout of this chapter. The chapter starts with an introduction indicating how this chapter is linked to the objectives of the study. It also provides an overview of what the chapter entails (section 4.1). The researcher then compares approaches and cost components used in similar studies in the seven international countries reviewed in Chapter 2 (section 4.2). In section 4.3, the researcher briefly discusses cost components common to all the SA studies reviewed in Chapter 3. The researcher also briefly explains how different countries disaggregate road crashes and injuries by severity (section 4.4). Section 4.5 presents the road crash assessment approach used in this study, which is a hybrid approach consisting of both the HCA and the WtPA. In 4.5, the researcher details the research methodology that was followed in this study to conduct the empirical research to investigate the WtPA within the SA context. Section 4.5 is critical since this study attempted to make a contribution by proposing a hybrid framework for assessing the costs of road traffic costs in SA. Lastly, the chapter concludes by providing a summary of the critical aspects of Chapter 4.

## 4.2 COMPARISON OF APPROACHES AND COST COMPONENTS USED INTERNATIONALLY

It is necessary to identify approaches and cost components commonly used internationally for road crash costs valuation. Once identified, these could be used to enhance approaches used in SA. This section compares the approaches and cost components used in studies conducted in the countries reviewed in Chapter 2 (see 2.3.1 and 2.3.2).

In the estimation of crash costs for Belgium, De Brabander and Vereeck (2007:717) identify three road crash cost categories together with the valuation method for each category as indicated in Table 2.16. De Brabander and Vereeck (2007:717) briefly explain the three categories as described below.

### 4.2.1 Human losses

Human losses are measured by the amount society is willing to pay to reduce the risk of road traffic crash injury**,** which in turn is estimated via a **RPM** or **SPM**. For a fatal casualty, the WtP also includes the discounted loss of consumption (De Brabander & Vereeck, 2007:717). However, following (European) traditional methodology, consumption is part of the gross output loss (De Brabander & Vereeck, 2007:717). In order to avoid double counting, consumption is subtracted from the amount society is willing to pay to avoid a road fatality and added to the net output loss. Since consumption is not lost for (non-fatally) injured casualties, the amount society is willing to pay to avoid a road injury does not include the value of lost consumption. Hence, there is no danger of double counting (De Brabander & Vereeck, 2007:717).

### 4.2.2 Production losses

'Production losses' refers to the loss of economic output. Since the victim's consumption is not lost by a non-fatal injury, it is gross output loss that is rightly taken into account (De Brabander & Vereeck, 2007:717). However, for fatal injuries, it is net output that is lost (De Brabander & Vereeck, 2007:717). However, for reasons of international methodological comparison, gross output loss (see 3.3.2.1) is applied for fatalities as well. Hence, the value of consumption lost by a fatal road victim is included in the production loss (and subtracted from the WtP) (De Brabander & Vereeck, 2007:717).

### 4.2.3 Crash costs

Crash costs comprise medical costs, hospital visiting costs, accelerated funeral costs, property damage, administrative costs of insurance companies, litigation costs, police and fire department costs, and congestion costs (De Brabander & Vereeck, 2007:717). The former three relate directly to the occurrence of injuries; the latter five, to the mere occurrence of a crash. Most of these costs lead to out-of-pocket expenses with the exception of the loss of interest on an accelerated funeral and the congestion costs of private household road users (De Brabander & Vereeck, 2007:717).

Even though they fall under the same cost categories as explained by De Brabander and Vereeck (2007:717) above, approaches used in the assessment of road crash costs in the seven countries discussed in Chapter 2 consider different and/or modified cost components. This section therefore compares cost components used in calculating road crash cost estimates for five of the seven countries, namely Australia, Belgium, United Kingdom, the Netherlands, and the United States of America as summarised in Table 4.1. These are countries that use the HCA for their assessment of road traffic crashes, even though two of them (Belgium and the United Kingdom) use the WtPA to calculate human costs (see Department for Transport, 2012; De Brabander & Vereeck, 2007).

Table 4.1 shows which cost components were used in road traffic crash cost assessment studies conducted in five countries, namely Australia, Belgium, the Netherlands, the United Kingdom and the United States of America. A 'Yes' indicates that studies reviewed in the applicable countries considered the cost component concerned while 'No' means they did not. For example, Belgium and the Netherlands considered production loss in their valuation of road traffic crashes whereas Australia, the United Kingdom and the United States of America did not consider this cost component.

**Table 4.1: Components of the cost of road crashes considered in Australia, Belgium, Britain, the Netherlands and the United States of America**

| | Component considered (Yes or No) | | | | |
|---|---|---|---|---|---|
| **Cost component** | **Australia** | **Belgium** | **Britain** | **Netherlands** | **United States** |
| Production loss | No | Yes | No | Yes | No |
| Lost output | No | No | Yes | No | No |
| Workplace and household losses | Yes | No | No | No | No |
| Market production | No | No | No | No | Yes |
| Household | No | No | No | No | Yes |
| Workplace | No | No | No | No | Yes |
| Repair costs | Yes | No | No | No | No |
| Property damage | No | No | Yes | Yes | Yes |
| Private property damage | No | Yes | No | No | No |
| Public property damage | No | Yes | No | No | No |
| Disability-related costs | Yes | No | No | No | No |
| Non-economic or non-pecuniary costs | Yes | No | No | No | No |
| Insurance administration | Yes | No | No | No | Yes |
| Insurance and administration | No | No | Yes | No | No |
| Administrative costs of insurance companies | No | Yes | No | No | No |
| Medical and related costs | Yes | No | No | No | No |
| Medical costs | No | Yes | No | Yes | Yes |
| Medical and ambulance | No | No | Yes | No | No |
| Hospital visiting costs | No | Yes | No | No | No |
| Travel delay and vehicle operating costs | Yes | No | No | No | No |

| Cost component | Component considered (Yes or No) | | | | |
|---|---|---|---|---|---|
| | Australia | Belgium | Britain | Netherlands | United States |
| Legal costs | Yes | No | No | No | Yes |
| Settlement costs | No | No | No | Yes | No |
| Private litigation costs | No | Yes | No | No | No |
| Public litigation costs | No | Yes | No | No | No |
| Vehicle unavailability costs | Yes | No | No | No | No |
| Costs of emergency and police services | Yes | No | No | No | No |
| Intervention costs by the police departments | No | Yes | No | No | No |
| Police cost | No | No | Yes | No | No |
| Workplace disruption | Yes | No | No | No | No |
| Emergency Medical Services (EMS) | No | No | No | No | Yes |
| Intervention costs by the fire departments | No | Yes | No | No | No |
| Ambulance | Yes | No | No | No | No |
| Health cost of crash-related induced pollution | Yes | No | No | No | No |
| Roadside objects damage cost | Yes | No | No | No | No |
| Correctional services (For convicted offenders) | Yes | No | No | No | No |
| Recruitment and re-training | Yes | No | No | No | No |
| Premature funeral cost | Yes | No | No | No | No |
| Accelerated funeral costs | No | Yes | No | No | No |
| Coronial costs | Yes | No | No | No | No |
| Congestion costs | No | Yes | No | Yes | Yes |
| Human costs | No | No | Yes | Yes | No |
| Quality Adjusted Life Years (QALYs) | No | No | No | No | Yes |

It is evident from Table 4.1 that there are cost components common to all five countries considered and those that are applied in a particular country only. For example:

- production loss is common to Belgium and the Netherlands;
- the United Kingdom, the Netherlands and the United States of America have property damage in common;
- insurance administration is considered by Australia and the United States of America;
- medical costs are common to Belgium and the United States of America;
- Australia and the United States of America both consider legal costs in the assessment of the cost of road traffic crash; and
- the United Kingdom and the Netherlands consider human costs as cost components in the valuation of the cost of road traffic crash.

Following are the ten cost components that are common to the five countries listed in Table 4.1. Each one of the cost components is discussed in terms of their relevance to road traffic crash cost valuation.

#### *4.2.3.1 Lost output*

In the studies to determine crash estimates for Belgium (see section 2.3.5) and the Netherlands (see 2.3.2) by SWOV (2012), De Brabander and Vereeck (2013) and Wijnen (2013), 'lost output' as British studies call it (see Department for Transport, 2007:2), is referred to as 'production loss'. In the case of Australian cost estimate components, Hendrie and Miller (2012:29) refer to this component as workplace and household losses consisting of market productivity and household productivity. Production loss entails loss of production and income resulting from the temporary or permanent disability of the injured, and the complete loss of production of fatalities (see sections 2.3.2 and 2.3.5). The potential loss of production is calculated, i.e. the monetary value of the contribution somebody would have made had such person not been injured or killed. In the case of the Netherlands, it does not matter whether the individual casualties were actually employed before the crash, or would have been employed in the future (Wijnen, 2013). In the case of fatalities, the total value of the production over the lost productive years is estimated and the present value is calculated, i.e. the production is weighted over those lost years (De Brabander & Vereeck, 2013; SWOV, 2012; Wijnen, 2013).

'Workplace costs' are defined as costs of workplace disruption due to the loss or absence of an employee as a result of a road traffic crash injury that are borne by employers (Hendrie & Miller, 2012). These include the cost of training new employees, overtime required to accomplish work of the injured employee, the administrative costs of processing personnel changes, output foregone and costs associated with hiring temporary employees (Blincoe, Miller, Zaloshnja & Lawrence, 2015:287; Hendrie & Miller, 2012:29). In addition to workplace costs, Blincoe et al. (2015:287) include vocational rehabilitation, which entails cost of job or career retraining required as a result of disability caused by motor vehicle injuries.

The next section discusses property damage costs as one of the crash cost components considered by international road traffic crash assessment studies reviewed for the purpose of this study.

#### *4.2.3.2 Property damage cost*

In Australian crash costing studies, property damage cost is divided into vehicle damage cost (repair costs) and roadside objects damage cost (BITRE, 2009:81; Hendrie & Miller, 2012:29). Hendrie and Miller (2012:29) define vehicle damage cost as consisting of vehicle repair costs, towing costs and the cost of vehicle unavailability. Roadside object-related property damage cost is the cost of repairing roadside objects (Hendrie & Miller, 2012:29). Blincoe, et al. (2015:12 &287), Institute for Road Safety Research [SWOV] (2012:2–3) and Wijnen (2013:3) define property damage as referring to damage to vehicles, freights, roads and fixed roadside objects. However, SWOV (2012:3) and Wijnen (2013:3) further emphasise that the majority of property damage concerns damage to vehicles. In the Netherlands, the estimation of these costs is based on insurance data, such as damage claims paid, estimates of the damage not claimed, and damage not compensated (Wijnen, 2013:3). Wijnen (2013:3) cautions though that one of the major problems regarding this cost component is the fact that not all damage is claimed, because not all damage is covered by insurances.

Medical costs are also cost components considered in international studies reviewed and reported on in Chapter 2 for the purpose of this study. This cost component is discussed in the next section.

#### *4.2.3.3 Medical costs*

In the Australian cost estimates, medical costs include ambulance, medical, hospital in-patient and paramedical costs (Bureau of Infrastructure, Transport and Regional Economics [BITRE], 2010:51; Hendrie & Miller, 2012:29). However, in the Netherlands, these costs include hospital costs, rehabilitation, medicines and adaptations for people with disabilities (Wijnen, 2013:13). The US medical cost estimates cover ambulance travel, emergency room and in-patient costs, follow-up visits, physical therapy, rehabilitation, prescriptions, prosthetic devices and home modifications (Blincoe et al., 2015:11). In the case of the United Kingdom, medical costs include ambulance, emergency department, hospital in-patient, blood transfusion services, district nurse services, cost of medical appliances and social security services (Hendrie & Miller, 2012:24). Just like the Netherlands and the United States of America that respectively include adaptations for people with disabilities, prosthetic devices and home modifications, Australia also includes disability-related costs. Disability-related costs are costs of providing care for people with a disability, including careers, specialist accommodation, therapy and specialist services, day programmes, aids and equipment, and home modifications (BITRE, 2010:54).

The next section discusses legal costs since this was one of the cost components considered in international literature reported on in Chapter 2.

#### *4.2.3.4 Legal costs*

In Australia and the United States of America, legal costs include legal fees and court cases associated with civil litigation resulting from traffic crashes (Blincoe et al., 2015:11; Hendrie & Miller, 2012:29). In Belgium, the costs are split between private and public litigation (De Brabander & Vereeck, 2007:717). The United Kingdom cost estimates however do not include legal costs (Hendrie & Miller, 2012:24).

Administrative costs are amongst the cost components considered by studies conducted in Australia, the United States of America, Belgium and the United Kingdom in the assessment of road traffic crash costs. This cost component is discussed in section 4.2.3.5 below.

#### *4.2.3.5 Administrative costs*

The Australian cost valuation approach identifies insurance administration and vehicle insurance claims where the former are administrative costs associated with processing insurance claims resulting from motor vehicle crashes whereas the latter are costs of administering the motor vehicle property damage insurance system (Hendrie & Miller, 2012:29). In the case of the Netherlands, only insurance administration costs are considered and these are settlement costs including expenses incurred by organisations such as the fire brigade, police, law courts and insurers (SWOV, 2012:2–3; Wijnen, 2013:3). The United States, Belgium and the United Kingdom only consider insurance administrative costs associated with processing insurance claims resulting from motor vehicle crashes and defence attorney costs (Blincoe et al., 2015:11; De Brabander & Vereeck, 2007:725; Department for Transport, 2007:13; 2012:4).

Section 4.2.3.6 discusses police costs as one of the cost components considered in road crash cost assessment studies in the five countries that used the HCA as demonstrated by the literature review reflected in Chapter 2, namely Australia, Belgium, United Kingdom, United States and the Netherlands.

#### *4.2.3.6 Police costs*

Whereas the United Kingdom names these just 'police costs' (Department for Transport, 2007:13; 2012: 4), Belgium refers to these costs as 'intervention costs by the police department' (De Brabander & Vereeck, 2007:725). The Netherlands include these costs under 'settlement costs' together with the fire brigade, law courts and administrative costs of insurers (Wijnen, 2013:3).

Emergency services costs are amongst the different cost components considered by studies that were conducted in Australia, Belgium, the Netherlands, the United Kingdom and the United States of America. These are discussed in the next section.

#### *4.2.3.7 Emergency services costs*

In Australia and the United States, emergency services include both the police and fire and rescue department response costs (Blincoe et al., 2015:11; Hendrie & Miller, 2012:29). However, in the case of the Netherlands, emergency services are included as part of insurance administration settlement costs together with the police, law courts and insurers (SWOV], 2012:2–3; Wijnen, 2013:3). The United Kingdom only considers police costs as emergency services costs (Hendrie & Miller, 2012).

One of the consequences of road traffic crashes is loss of quality of life by victims. International road crash cost assessment literature discussed in Chapter 2 also includes this cost component in their crash cost valuation. This cost component is discussed in the following section.

#### *4.2.3.8 Loss of quality of life/human cost*

These are immaterial costs through suffering, pain, sorrow and loss of quality of life by casualties (SWOV, 2012:2–3; Wijnen, 2013:3). Human losses are measured by conducting a survey about the amount of money people are willing to pay for a certain reduction in crash rate or to avoid pain, grief and suffering of the casualty, relatives and friends as well as intrinsic loss of enjoyment of life in the case of fatalities (De Brabander & Vereeck, 2007:717; Hendrie & Miller, 2012:24; SWOV, 2012:2–3; Wijnen, 2013:3). This element is estimated via an RPM or SPM and for a fatal casualty; the WtP also includes the discounted loss of consumption (Wijnen, 2013:3). These surveys are used to determine the VoSL, which is used to calculate the human losses. The WtPA is used in the Netherlands, the United Kingdom, Singapore and Egypt. However, in the case of Australia, where a hybrid

HCA is used, personal injury awards ascribed by the Transport Accident Commission of Victoria are regarded as a proxy for individual pain and suffering (Hendrie & Miller, 2012:29).

Road traffic crashes have an adverse effect on traffic flow resulting in congestion or travel delays for road users not necessarily involved in the crash. International studies that were conducted in four of the five countries reported on in Chapter 2, namely Australia, Belgium, the Netherlands, and the United States also considered costs resulting from congestion or travel delays as one of the cost components. This cost component is discussed in section 4.2.3.9 below.

#### *4.2.3.9 Congestion cost/travel delays*

Congestion cost is the value of travel delay for persons who are not involved in traffic crashes but who are delayed in the resulting traffic congestion from these crashes (Blincoe et al., 2015:69). These costs are considered in the estimation of road crash costs in Australia, Belgium, the Netherlands and the United States (Bureau of Infrastructure, Transport and Regional Economics [BITRE], 2010:69; De Brabander & Vereeck, 2007:725; Hendrie & Miller, 2012:24; SWOV, 2014:2–3; Wijnen, 2013:3). They are however not considered in the calculation of crash estimates in the United Kingdom (Hendrie & Miller, 2012:24).

The worst consequence of a road traffic crash is death, which necessitates expenditure on funerals of victims. This was treated as a cost component in international studies reported on in Chapter 2. The next section discusses this cost component briefly.

#### *4.2.3.10 Premature or accelerated funeral costs*

These are costs of funerals of fatalities that result from road crashes. Australia and Belgium consider this as a separate cost component in the estimation of the cost of crashes (Bureau of Infrastructure, Transport and Regional Economics [BITRE], 2010:84; De Brabander & Vereeck, 2007:7250).

In order to be able to compare international best practice as discussed in Chapter 2 with the SA practice in terms of cost components considered in the assessment of road traffic crashes, it was critical to review previous SA studies as well. This enabled the identification of cost components commonly used in all eight SA road crash assessment studies relative to those used internationally. In case there are components commonly used internationally that are not used in South Africa, these could be added to the country's list of cost components. A review of previous SA road crash cost assessment studies therefore follows in section 4.3.

## 4.3 COST COMPONENTS USED IN PREVIOUS SOUTH AFRICAN STUDIES

Eight SA studies from 1965 to 2016 were reviewed to identify cost components used in each one of them for purposes of assessing the costs of road crashes in the country as illustrated in Table 4.2 below. A 'Yes' shows that the corresponding cost component is included in the study whereas a 'No' indicates that the cost component was not considered in the corresponding study.

**Table 4.2: Comparison of cost components and total cost estimates of previous SA studies**

| | Component considered (Yes or No) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Cost component** | **Cillié (1975)** | **Cillié & Freeman (1977)**[35] | **Goosen & Kolman (1982)**[36] | **Verburgh et al. (1985)** | **Glass & Hamilton (1987)** | **Morden (1989)** | **Schutte (2000)** | **Labuschagne (2016)** |
| Loss of output | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Damage to property | Yes | Yes | Yes | Yes | Yes | No | Yes [37] | Yes[38] |
| Vehicles | No | No | No | No | No | Yes | No | Yes |
| Goods in transit | No | No | No | No | No | Yes | No | No |
| Infrastructure damage | No | No | No | No | No | No | No | Yes |
| Pain, suffering and loss of amenities of life | No | No | No | No | No | Yes | Yes | Yes |
| Medical costs | Yes | Yes | Yes | Yes | Yes | No | No | Yes |
| Hospital, medical and funeral costs | No | No | No | No | No | No | Yes | No[39] |
| Hospital | No | No | No | No | No | Yes | No | No |
| Medical | No | No | No | No | No | Yes | No | No |
| Funeral | No | No | No | No | No | Yes | No | Yes |
| Administrative costs | Yes | Yes | Yes | Yes | No | Yes | Yes | |
| Legal costs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Insurance administrative costs | No | No | No | No | Yes | No | No | No |
| Miscellaneous costs | No | No | No | No | Yes | No | Yes [40] | No |
| Loss of time | No | No | No | No | No | Yes | No | Yes[41] |

[35] This study also included projections of crash costs for two subsequent years, namely 1976 and 1977.

[36] Instead of legal proceedings by the state, this study estimated legal costs per involvement (Goosen & Kolman, 1982:35–36).

[37] Schutte considered vehicle damage as the only variable under damage to property.

[38] With vehicle and infrastructure costs treated as separate cost components.

[39] Funeral and medical costs treated as separate cost components. No hospital costs considered.

[40] Schutte only considered time lost, towing cost and other (such as flowers, attending hospitals and funerals and completing forms).

| | Component considered (Yes or No) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Cost component** | **Cillié (1975)** | **Cillié & Freeman (1977)**[35] | **Goosen & Kolman (1982)**[36] | **Verburgh et al. (1985)** | **Glass & Hamilton (1987)** | **Morden (1989)** | **Schutte (2000)** | **Labuschagne (2016)** |
| Police | No | No | No | No | Yes | Yes | No | |
| Other variable costs | No | Yes | Yes | Yes | No | No | No | No |
| Non-variable costs | No | No | Yes | No | No | No | No | No |
| Work place re-occupation | No | No | No | No | No | No | No | Yes |
| Road traffic crash scene attendance and clean-up | No | No | No | No | No | No | No | Yes |

Note: Yes=Cost component was considered in the study; No=Cost component was not considered in the study

Table 4.2 indicates that:

- all eight studies in Table 4.2 considered loss of output and legal costs as cost components in the assessment of road traffic crash costs;
- seven of the eight studies (Cillié, 1975; Cillié & Freeman, 1977; Glass & Hamilton, 1987; Goosen & Kolman, 1982; Labuschagne, 2016; Schutte, 2000; Verburgh et al., 1985) include damage to property cost as a cost component;
- the studies by Morden (1989), Schutte (2000) and Labuschagne (2016) considered pain, suffering and loss of amenities of life as a cost component;
- six of the eight studies (Cillié, 1975; Cillié & Freeman, 1977; Glass & Hamilton, 1987; Goosen & Kolman, 1982; Labuschagne, 2016; Verburgh et al., 1985) included medical costs;
- the studies by Morden (1989) and Labuschagne (2016) considered funeral costs;
- seven of the eight studies (Cillié, 1975; Cillié & Freeman, 1977; Goosen & Kolman, 1982; Labuschagne, 2016; Morden, 1989; Verburgh et al., 1985) considered administrative costs;
- the studies by Morden (1989) and Labuschagne (2016) included loss of time as a cost component;
- miscellaneous costs were only included in the studies by Glass and Hamilton (1987) and Schutte (2000);
- police costs were only included in the studies by Glass and Hamilton (1987) and Morden (1989); and

[41] Including greenhouse gas emissions.

- other variable costs were included in the studies by Cillié and Freeman (1977), Goosen and Kolman (1982) and Verburgh et al. (1985).

Sections 4.3.1 to 4.3.8 discuss cost components that were considered in at least three of the studies referred to in Table 4.2.

### 4.3.1 Loss of output

When a working person is killed in a road crash, the community loses his or her production for what would have been the remainder of his or her working life (Cillié, 1975:7; Cillié & Freeman, 1977:12). Therefore, loss of output due to fatalities (premature death) is defined as the output that would have been produced over the remainder of the economic lives of those people killed in road crashes (Schutte, 2000:4-3; Wijnen et al., 2016:9). Furthermore, when an employed person is unable to work because of a car crash injury, the community loses his or her production for the duration of his or her incapacity (Cillié, 1975:8; Goosen & Kolman, 1982:14; Labuschagne, 2016:27). Despite the fact that Cillié (1975:8–9) also considered loss of unpaid services provided by housewives, subsequent studies only considered loss of output due to death, serious injury as well as slight injury (see sub-section 3.3.2.1 above).

All the SA studies also considered damage to property costs as a component. This cost component is discussed in 4.3.2.

### 4.3.2 Damage to property costs

As it is evident from Table 4.2, damage to property cost was considered a cost component in all the eight SA studies considered for the purpose of this research. Apart from Labuschagne (2016:38–39) who separated vehicle repair costs from infrastructure damage costs, all the other studies identified vehicle damage costs, goods in transit costs and goods outside the vehicle as sub-components of the damage to property component (see sub-section 3.3.2.2).

The SA studies also consistently included medical costs as one of the cost components considered in their valuation of road traffic crash costs. This cost component is discussed in the next section.

### 4.3.3 Medical costs

Medical costs arising from road crashes obviously only result from injury crashes, i.e. a crash in which there is at least one casualty, whether slight, serious or fatal (Cillié, 1975:37; Cillié & Freeman, 1977:15; Goosen & Kolman, 1982:26; Verburgh et al., 1985:22; Wijnen et al., 2016:9). These mainly comprise four cost types, namely:

- the cost of treatment by professional medical and para-medical practitioners such as doctors, dentists, surgeons, anaesthetists, osteopaths, nurses, physiotherapists, and occupational therapists, amongst others;
- the fees charged by hospitals and nursing homes, both for in-patients and out-patients, for hospitalisation and ancillary services;
- the cost of supplies and medications purchased by crash victims whether on prescription or not; and
- ambulance costs (Cillié, 1975:37; Cillié & Freeman, 1977:15; Goosen & Kolman, 1982:26; Verburgh et al., 1985:22–23; Wijnen et al., 2016:9).

Labuschagne (2016:29) defines medical treatment costs as costs of medical treatment on the scene of the crash or in a private or public hospital, either uncompensated or compensated by medical aid or the RAF.

Table 4.2 shows that all previous SA studies reviewed for the purpose of this study included medical costs as a cost component of road traffic crashes. Cillié (1975), Cillié and Freeman (1977), Glass and Hamilton (1987), Goosen and Kolman (1982) and Verburgh et al. (1985) refer to this component exactly as it is called internationally, i.e. ‘medical costs’. However, Morden (1989) splits the medical cost component into three components, namely hospital, medical and funeral costs. Schutte (2000) combined the three cost components as considered by Morden (1989) into one cost component, which he called hospital, medical and funeral costs (see sub-section 3.3.2.3).

The next cost component considered in previous SA studies to be discussed is the legal costs.

### 4.3.4 Legal costs

As stated in sub-section 3.3.2.5 above, legal costs arising from road crashes are fully chargeable as variable crash costs, and they are borne by insurance companies, vehicle owners or drivers, crash casualties or their dependants, and the state (Cillié, 1975:48; Cillié & Freeman, 1977:18; Goosen & Kolman, 1982:35; Labuschagne, 2016:31; Verburgh et al., 1985:30). These costs are incurred, amongst others, when there is a legal dispute among crash victims regarding liability, when legal proceedings are instituted by the state against one or more of the people who were involved in the crash, during the preparation of certain claims by policyholders or claimants, and during the investigation and settlement of claims by insurance companies (Cillié, 1975:48; Cillié & Freeman, 1977:18; Goosen & Kolman, 1982:35; Schutte, 2000:4–5; Verburgh et al., 1985:30). As is evident from Table 3.11, all previous SA studies reviewed referred to this cost component as ‘legal costs’.

Numerous costs of administrative nature are incurred in the handling of a crash. These are referred to as administrative costs (see Cillié, 1975:48). Previous SA studies (such as Morden, 1989; Schutte, 2000) treated this as a cost component in the assessment of the costs of road traffic crashes. In 4.3.5 a brief discussion of this component is provided.

#### 4.3.5 Administrative costs

Administrative costs attributed to road crashes comprise two groups, namely costs incurred by the police in the investigation and recording of crashes, and the variable (or semi-variable) administrative costs of companies, which transact motor vehicle insurance business (Cillié & Freeman, 1977:17; Glass & Hamilton, 1987:28–32; Verburgh et al., 1982:27–29). Labuschagne (2016:31) identified road traffic scene attendance and clean-up, data capturing, analysis and reporting as well as investigation and reconstruction as components of the incident costs category. These are evidently administrative costs if we consider the naming convention of studies conducted prior to Labuschagne's study in 2016 cited at the beginning of this section. With the exception of the study by Glass and Hamilton (1987), which only considered insurance administrative costs, all six of the other studies considered police costs and insurance administration costs as sub-components of administrative costs (see sub-section 3.3.2.4).

The SA studies also considered the loss of quality of life experienced by road traffic crash victims. In line with international studies, they refer to the cost component that caters for this loss as the cost of pain, suffering and loss of amenities of life (see Morden, 1989; Schutte, 2000; Labuschagne, 2016). This cost component is discussed in section 4.3.6.

#### 4.3.6 Pain, suffering and loss of amenities of life

Morden (1989:24) asserts that many people injured in road traffic crashes suffer severe and prolonged pain, suffering and loss of amenities of life. If an injured person's quality of life is reduced as a direct result of a crash, he or she is rightfully entitled to some measure of compensation (Morden, 1989:24). However, despite the fact that this component is important, there is little or no information available to quantify it, and it also excludes the costs suffered by the family of the victim (Schutte, 2000:4-5). As a result, like BITRE (2009) and, Hendrie and Miller (2012:29) that used the Transport Accident Commission (TAC) victim compensation information, the studies by Schutte (2000) and Labuschagne (2016) also used compensation information from the RAF as a proxy for this cost component. In the RAF awards, compensation is awarded with respect to:

- medical and hospital expenses;
- loss of income;
- general damages, such as:

    - scarring;
    - pain and suffering; and
- a proportion of the legal and medico-legal costs to finalise the claim (Morden, 1989:25).

The SA studies also considered other variable costs that do not fall under any of the specific cost components discussed above. The studies refer to these as other variable costs (Cillié & Freeman, 1977; Goosen & Kolman, 1982; Verburgh et al., 1985). These are discussed in section 4.3.7 below.

#### 4.3.7 Other variable costs

Other variable costs consist of –

- loss of time due to recording the crash, filling out a claim form, taking the car to the assessor, taking it to and collecting it from panel beaters, engaging other people to provide alternative transport means, taking injured persons to hospital, fetching people from hospital and/or making funeral arrangements); and
- miscellaneous incidental expenses, such as telephone calls, telegrams, flowers and vehicle towing expenses (Cillié & Freeman, 1977:19; Goosen & Kolman, 1982:40). This component was introduced for the first time by Cillié and Freeman (1977:19–20) in an attempt to ensure completeness of cost estimates.

There are also non-variable costs that are incurred as a result of road traffic crashes. The SA studies reviewed in Chapter 3 also considered these costs as cost components in the valuation of the costs of road traffic crashes in South Africa. These are therefore discussed below.

#### 4.3.8 Non-variable costs

Some of the fixed costs that fall under this component are debatable as to whether or not they are strictly crash costs (Cillié & Freeman, 1977:21). For instance, it is not clear whether the cost of road policing and enforcement is chargeable in part to road crashes, and if so, to what extent (Goosen & Kolman, 1982:41). It can be argued, on the one hand, that the cost is incurred to promote the smooth functioning of the road system in general and that it is not related to road crashes, but it is likely, on the other hand, that road policing costs are influenced to some degree at least by crash occurrence (Cillié & Freeman, 1977:21; Goosen & Kolman, 1982:41).

As Table 3.14 shows, Cillié and Freeman (1977:6) and Goosen and Kolman (1982:4) identified costs of processing and publishing road crash statistics, costs of policing and traffic control, costs incurred by vehicle manufacturers in designing vehicles of higher safety standards, and costs incurred by road authorities in designing and constructing safer roads as administrative costs categorised as non-variable crash costs. Verburgh et al. (1985:39–40) identified road safety research and promotion costs as well as costs of processing and publishing traffic crash data as non-variable crash costs. Glass and Hamilton, 1987:39–40) also introduced crash prevention and data collection costs as sub-components of non-variable crash costs (see sub-section 3.3.1.7 and Table 4.2).

In order to avoid complex theoretical arguments and also because fixed crash costs are very minor compared to variable costs, the studies by Cillié (1975), Cillié and Freeman (1977) as well as Goosen and Kolman (1982) only considered two items, namely non-variable administrative costs and the cost of road safety research and promotion. Verburgh et al. (1985:39–40) treat road safety research and promotion costs as well as cost of processing and publishing road crash statistics as separate components.

Road traffic crashes and injuries are of different levels of severity, and different countries use different terminology to disaggregate road crashes and injuries accordingly. The next section explains briefly how different countries categorise road crashes by severity.

## 4.4 DISAGGREGATION OF ROAD TRAFFIC CRASHES AND INJURIES BY SEVERITY

Bureau of Infrastructure, Transport and Regional Economics [BITRE] (2010:40) identifies four road crash injury severity categories for Australia, namely fatalities, hospitalised injuries admitted for one or more bed nights, hospitalised – admitted and discharged the same day, non-hospitalised injuries and minor injuries. Four road crash types are also identified: fatal, hospitalised injury crashes, non-hospitalised injury crashes and property damage only crashes (Bureau of Infrastructure, Transport and Regional Economics [BITRE], 2010:13). In the case of the United States, Blincoe et al. (2015:11) divide crash outcomes into property damage only (vehicle), MAIS0, MAIS1, MAIS2, MAIS3, MAIS4, MAIS5 and fatal crashes, where MAIS stands for maximum abbreviated injury scale (Blincoe et al., 2015).

In line with the other countries as discussed in Chapter 2, it is evident from Chapter 3 that all SA studies divide crash severity into four types, namely fatal, serious injury, slight injury and damage only crashes. Chapters 2 and 3 as well as the preceding sections of this chapter reflected both international and SA road traffic cost assessment studies and identified good practice in terms of cost components considered. Informed by the review of international and SA literature in Chapters 2 and 3, section 4.5 presents a detailed approach that was used in the current study and which is also proposed as a hybrid framework for future use in the assessment of the costs of road traffic crashes in South Africa.

Noteworthy is the fact that the approach proposed in this study is provided as an illustration of how the hybrid approach could be applied and resulting cost estimates do not reflect the real case at hand.

### 4.5 ROAD CRASH ASSESSMENT APPROACH USED IN THIS STUDY

It needs to be emphasised that beyond the individuals and families directly affected by individual road crashes, direct and indirect costs are borne by a range of parties, such as government, insurers, employers and other road users. In order to achieve greater clarity on the relevant costs and on whom these costs fall, different data were required. In line with cost components identified through both review of international and SA literature, Davies and Newman (2015:13) divide costs of trauma into three major components:

- direct costs – associated with emergency services responding to crashes, medical, paramedical and rehabilitation expenses and legal and insurance administration-related costs;
- indirect costs – associated with premature death, permanent impairment or temporary absence from work caused by crashes borne by injured parties or their family, dependants or carers; and
- economic valuations – particularly of lost quality of life.

These components are detailed in Table 4.3 identifying the different stakeholders that are affected by road trauma.

**Table 4.3: Stakeholders affected by road trauma by cost component**

| STAKEHOLDER | EMERGENCY SERVICES | HEALTH | INCOME | DEPENDENCY | PROPERTY | ADMINISTRATION |
|---|---|---|---|---|---|---|
| **GOVERNMENT** | • Police and emergency service response costs | • Uninsured public hospitalisation and allied health or medical costs | • Loss of GDP and taxation revenue | • Welfare (safety net) payments to injured parties, dependants and carers | • Infrastructure repair and remediation costs | • Welfare administration costs |
| **INJURED PARTIES AND THEIR FAMILIES, DEPENDANTS AND CARERS** | • Uninsured ambulance costs | • Uninsured funeral costs<br>• Uninsured private medical and paramedical costs, including rehabilitation<br>• Uninsured pharmaceutical aids and equipment costs | • Uninsured loss of income (including carer income) | • Uninsured dependency and carer costs | • Uninsured vehicle repair and replacement costs | • Uninsured legal costs |
| **INSURERS** | • Insured ambulance costs | • Insured funeral costs<br>• Insured medical and paramedical costs, including rehabilitation<br>• Insured pharmaceutical aids and equipment costs<br>• Compensation for pain and suffering/impairment | • Income insurance payments | • Life and dependency insurance payments | • Insured vehicle repair and replacement costs | • Insurance claims administration and legal costs |
| **CORPORATE TRANSPORT NETWORK USERS AND EMPLOYEES** | • Uninsured ambulance costs | • Uninsured worker-related funeral and medical and paramedical costs, including rehabilitation<br>• Uninsured pharmaceutical aids and equipment costs | • Workplace disruption<br>• Loss of income/productivity<br>• Recruitment and (re)training | • Uninsured dependency and carer costs | • Uninsured vehicle repair and replacement costs | • Uninsured legal costs |

*Source: Davies and Newman (2015:15).*

Despite the different cost components borne by the different stakeholders outlined in Table 4.3, different countries consider different cost components in the assessment of crash costs. This section compares components used in the seven studies reviewed in Chapter 2 for Australia, Belgium, Egypt, the Netherlands, Singapore, the United Kingdom and the United States of America with those used in SA studies. The comparison helps to identify cost components common to all seven countries. A further comparison is made between cost components common in the approaches used to assess crash costs for the seven countries and those commonly used in all SA traffic crash cost assessment studies reviewed in Chapter 3. This comparison culminates in the identification of cost components that are common to all international studies and those conducted in South Africa. Given the currency of the international studies reviewed, components that are new are added to those that were found to be common in both the international and SA studies to come up with a hybrid framework for use in the current study and future valuation studies to assess crash costs for South Africa.

The preceding sub-sections summarised implications of literature reviewed on approaches and key cost components as used in the seven countries and South Africa in the assessment of the cost of road crashes reflected in Chapters 2 and 3 respectively. As was evident in Table 1.1, South Africa consistently used the HCA for all the road crash cost assessment studies that were conducted by the CSIR on behalf of the DoT. However, of the seven countries considered for international literature review purposes, Australia, Belgium, the Netherlands, the United Kingdom and the United States, were found to use the same approach. It needs to be indicated however that three of these countries, namely Belgium, the Netherlands and the United Kingdom, use the WtP to calculate human costs. Furthermore, studies conducted in Egypt and Singapore use the WtPA to assess the costs of road traffic crashes. The fact that there is a shift by a sizeable number of countries towards the use of the WtPA calls for South Africa to reconsider the observed religious reliance on the HCA and to explore the use of the WtPA to ensure that her crash cost estimates are comparable globally. It is for this reason that the second secondary objective of this study (see section 1.3.2 for secondary objectives) intended to investigate the WtPA empirically in the SA context. In order to be able to determine the comparability of the cost estimates of the HCA and the WtPA as envisaged by the third secondary objective, this study started by reviewing literature on international practice on the assessment of road traffic crashes thus achieving secondary objective 1 (see section 1.3.2 for secondary objectives). The literature review also enabled the structuring of the components of, and the relationship between, the HCA and the WtPA as envisaged by secondary objective 4 (see section 1.3.2 for secondary objectives).

The current study consequently used both the WtPA and the HCA. However, in the case of the HCA, instead of calculating the cost estimates from scratch, the estimates in the 2016 Cost of Crashes in South Africa report (see Labuschagne, 2016) were adjusted for inflation using the 2017 inflation rate of 5.3% (Stats SA, 2018b:5). In the current study, crash costs calculated using these two different methods are compared in Chapters 5 and 6 to establish whether there is any difference in line with the third secondary objective of this study (see section 1.3.2 for secondary objectives).

In 4.5.1, a detailed outline follows of how each one of the approaches was employed in terms of cost components and formulae that were used.

### 4.5.1 HCA

According to De Dios Ortúzar and Willumsen (2011:524), the HCA "is based on the assumption that the value of an individual is what they produce, and this is usually measured by the gross salary received at work (i.e. before taxes in order to include the government and hence society)".

Therefore, if the person dies, this production is lost. The literature review reported in Chapters 2 and 3 reflected international and SA studies. This sub-section focuses on practices of studies that assessed the cost of road traffic crashes using the HCA. The literature review identified ten cost components that this study recommends for similar future studies since Labuschagne (2016) also considered them in the study from which the HCA-based cost estimates in this study were updated for inflation. Various cost components are applicable of which the following were used in the current study: lost output, cost of property damage, medical costs, legal costs, pain, suffering and loss of amenities of life, premature or accelerated funeral costs, administrative costs, cost of emergency services, cost of congestion and travel delays as well as non-variable costs. These cost components are discussed in section 4.5.1.1.

#### *4.5.1.1 Cost components*

Following is a brief discussion of each of the cost components used in the current study.

*(a) Lost output*

When a working person is killed in a road crash, the community loses his or her production for what would have been the remainder of that person's working life (Cillié, 1975:7; Cillié & Freeman, 1977:12). Production loss refers to the loss of production and income resulting from the temporary or permanent disability of the injured, and the complete loss of production due to fatalities (De Brabander & Vereeck, 2007:717; SWOV, 2012:2–3; Wijnen, 2013:3). Therefore, loss of output due to fatalities (premature death) is defined as the output that would have been produced over the remainder of the economic lives of those people killed in road crashes (Schutte, 2000:4–3). Furthermore, when an employed person is unable to work because of a car crash injury, the community loses that person's production for the duration of his or her incapacity (Cillié, 1975:8, Goosen & Kolman, 1982:14; Labuschagne, 2016:27). Therefore, the potential loss of production is calculated, i.e. the monetary value of the contribution somebody would have made had they not been injured or killed, for inclusion as a cost component in the calculation of the cost of road traffic crashes.

*(b) Property damage cost*

In Australia, property damage cost is divided into vehicle damage cost (repair costs) and roadside objects damage cost (BITRE (Bureau of Infrastructure, Transport and Regional Economics), 2010:81; Hendrie & Miller, 2012:29). Hendrie and Miller (2012:29) define vehicle damage cost as consisting of vehicle repair costs, towing costs and the cost of vehicle unavailability. Roadside object-related property damage cost is the cost of repairing roadside objects (Hendrie & Miller, 2012:29). Blincoe et al. (2015:12 & 287), (SWOV 2012:2–3) and Wijnen (2013:3) define property damage as referring to damage to vehicles, freights, roads and fixed roadside objects. However, SWOV (2012:3) and Wijnen (2013:3) further emphasise that the majority of property damage concerns damage to vehicles.

In SA crash cost assessment studies, property or material damage caused by road crashes comprised:

- damage to vehicles;
- damage to objects inside vehicles and the personal effects of casualties and occupants (such as vehicle cargoes, clothing, spectacles and wrist watches); and
- damage to objects outside vehicles, whether fixed or moveable (roadside objects or fixed property) (Cillié, 1975:31; Cillié & Freeman, 1977:14; Glass & Hamilton, 1987:18; Goosen & Kolman, 1982:21; Labuschagne, 2016:30; Schutte, 2000:4-4; Verburgh et al., 1985:19).

Considering the definitions of property damage above, both internationally and locally, for the purpose of this study, property damage was considered vehicle damage costs and roadside objects or infrastructure cost. The study was further informed by the definition of Hendrie and Miller (2012:29) which defines vehicle damage cost as consisting of vehicle repair costs, towing costs and the cost of vehicle unavailability; and roadside object-related property damage cost as the cost of repairing roadside objects.

*(c) Medical cost*

In the Australian cost estimates, medical costs include ambulance, medical, hospital in-patient and paramedical costs (Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2009:51; Hendrie & Miller, 2012:29). However, in the Netherlands, these costs include hospital costs (which are the same as hospital in-patient costs), rehabilitation, medicines and adaptations for people with disabilities (Wijnen, 2013:13). The United States medical cost estimates cover ambulance travel, emergency room and in-patient costs, follow-up visits, physical therapy, rehabilitation, prescriptions, prosthetic devices and home modifications (Blincoe et al., 2015:11). In the United Kingdom, medical costs include ambulance, emergency department, hospital in-patient costs, blood transfusion services, district nurse services, costs of medical appliances and social security services (Hendrie & Miller, 2012:24). Just like the Netherlands and the United States that both include adaptations for people with disabilities, prosthetic devices and home modifications, Australia includes disability-related costs. Disability-related costs are costs of providing care for people with a disability including careers, specialist accommodation, therapy and specialist services, day programmes, aids and equipment, and home modifications (Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2009:54).

In the case of SA road crash cost assessment studies (Cillié, 1975:37; Cillié & Freeman, 1977:15; Goosen & Kolman, 1982:26; Verburgh et al., 1985:22–23), medical costs mainly comprise four cost types, namely:

- the cost of treatment by professional medical and para-medical practitioners, such as doctors, dentists, surgeons, anaesthetists, osteopaths, nurses, physiotherapists and occupational therapists, amongst others;
- the fees charged by hospitals and nursing homes, both for in-patients and out-patients, for hospitalisation and ancillary services;
- the cost of supplies and medications purchased by crash victims whether on prescription or not; and
- ambulance costs.

In the most recent SA study, Labuschagne (2016:29) defines medical treatment costs as costs of medical treatment on scene or in a private or public hospital, either uncompensated or compensated by medical aid or the RAF.

Therefore, for the purpose of this study, medical costs include costs of ambulance services, cost of supplies and medications purchased by crash victims whether on prescription or not, hospital in-patients and out-patients, and the cost of treatment by professional medical and paramedical practitioners, such as doctors, dentists, surgeons, anaesthetists, osteopaths, nurses, physiotherapists and occupational therapists.

*(d) Legal cost*

In Australia and the United States, legal costs include legal fees and court cases associated with civil litigation resulting from traffic crashes (Blincoe et al, 2015:11; Hendrie & Miller, 2012:29). In Belgium, the costs are specified as private and public litigation (De Brabander & Vereeck, 2007:717).

In the case of South Africa, legal costs arising from road crashes are fully chargeable as variable crash costs, and they are borne by insurance companies, vehicle owners or drivers, crash casualties or their dependants, and the state (Cillié, 1975:48; Cillié & Freeman, 1977:18; Goosen & Kolman, 1982:35; Labuschagne, 2016:31; Verburgh et al, 1985:30). These costs are incurred, amongst others, when there is a legal dispute among crash participants regarding liability, when legal proceedings are instituted by the state against one or more of the participants, during the preparation of certain claims by policyholders or claimants, and during the investigation and settlement of certain claims by insurance companies (Cillié, 1975:48; Cillié & Freeman, 1977:18; Goosen & Kolman, 1982:35; Schutte, 2000:4–5; Verburgh et al., 1985:30).

The SA definition of legal costs details what Australia, the United States and Belgium refer to as legal fees and court cases associated with civil litigation resulting from traffic crashes. The current study was therefore premised on the SA definition of legal costs.

*(e) Pain, suffering and loss of amenities of life*

In Australia where a hybrid HCA is used, personal injury awards ascribed by the Transport Accident Commission (TAC) of Victoria are regarded as a proxy for individual pain, suffering and loss of amenities of life (Hendrie & Miller, 2012:29). This cost is considered in the assessment of crash costs in Australia and the United States of America.

In South Africa, Morden (1989:24) asserts that many people injured in road traffic crashes suffer severe and prolonged pain, suffering and loss of amenities of life. If an injured person’s quality of life is reduced as a direct result of a crash, they are rightfully entitled to some measure of compensation (Hendrie & Miller, 2012:29). However, despite the fact that this component is important, there is little or no information available to quantify it, and it also excludes the costs suffered by the family of the victim (Schutte, 2000:4–5). As a result, just as BITRE (2009) used the TAC victim compensation information (see Hendrie & Miller; 2012:29); SA studies by Morden (1989), Schutte (2000) and Labuschagne (2016) also used compensation information from the RAF as a proxy for this cost component. According to the RAF, compensation is awarded with respect to:

- medical and hospital expenses;
- loss of income;
- general damages, such as:
    - scarring;
    - pain and suffering; and
- a proportion of the legal and medico-legal costs to finalise the claim (Morden, 1989:25).

For the purpose of this study, the Australian and SA approaches of using the TAC and RAF awards as a proxy of this component were applied for the 2016 HCA study (see Labuschagne, 2016) from which the inflation-adjusted cost estimates were taken.

*(f) Premature or accelerated funeral costs*

Premature or accelerated funeral costs are costs of funerals of fatalities that result from road crashes. Australia and Belgium consider this a separate cost component in the estimation of the cost of crashes (BITRE, 2009:84; De Brabander & Vereeck, 2007:7250). However, SA studies include this cost component in the medical cost and call it 'hospital, medical and funeral costs' (Labuschagne, 2016; Morden, 1989; Schutte, 2000).

For the purpose of the current study, this cost is treated as a stand-alone cost component, which, in line with Labuschagne's (2016:29) definition (see 3.3.2.8), covers the funeral and cremation expenses.

*(g) Administrative costs*

The Australian road crash cost valuation approach identifies insurance administration and vehicle insurance claims where the former refers to administrative costs associated with processing insurance claims resulting from motor vehicle crashes whereas the latter are costs of administering the motor vehicle property damage insurance system (Hendrie & Miller, 2012:29). In the case of the Netherlands, only insurance administration costs are considered, and these are settlement costs including expenses incurred by organisations such as the fire brigade, police, law courts and insurers (SWOV. 2012:2–3; Wijnen, 2013:3). The United States, Belgium and the United Kingdom only consider insurance administrative costs associated with processing insurance claims resulting from motor vehicle crashes and defence attorney costs (Blincoe et al, 2015:29; De Brabander & Vereeck, 2007:725; Department for Transport, 2007:13; 2012:4).

In South Africa, administrative costs associated with road crashes are considered to comprise two groups, namely costs incurred by the police in the investigation and recording of crashes; and the variable (or semi-variable) administrative costs of companies that transact motor vehicle insurance business (Cillié & Freeman, 1977:17; Glass & Hamilton, 1987:28-32; Verburgh et al., 1982:27-29). With the exception of the 1987 study by Glass and Hamilton, which only considered insurance administrative costs, the other six studies considered police costs and insurance administration costs as sub-components of administrative costs (see sub-section 3.3.2.4 and Table 3.10).

Just as in the case of Australia, in the current study, administrative costs entail insurance administration and vehicle insurance claims where the former are administrative costs associated with processing insurance claims resulting from motor vehicle crashes whereas the latter are costs of administering the motor vehicle property damage insurance system (Hendrie & Miller, 2012:29).

*(h) Emergency services cost*

In studies conducted in Australia and the United States, emergency services include both police and fire and rescue department response costs (Blincoe et al, 2015:11; Hendrie & Miller, 2012:29). However, in the case of the Netherlands, emergency services are included as part of insurance administration settlement costs together with police, law courts and insurers (SWOV. 2012, 2–3; Wijnen, 2013:3). The United Kingdom only considers police costs as emergency services costs (Hendrie & Miller, 2012).

In South Africa, costs incurred by the police in the investigation and recording of crashes are treated as part of administrative costs (Cillié & Freeman, 1977:17; Glass & Hamilton, 1987:28-32; Verburgh et al., 1982:27–29).

In the current study, the costs of emergency services include both police and fire and rescue department response costs as categorised by Hendrie and Miller (2012:29) and Blincoe et al (2015:11).

*(i) Congestion cost and/or travel delays*

Congestion cost is the value of travel delays for persons who are not involved in traffic crashes but who are delayed in the resulting traffic congestion from these crashes (Blincoe et al, 2015:69). These costs are considered in the estimation of road crash costs in Australia, Belgium, the Netherlands and the United States (BITRE, 2009:69; De Brabander & Vereeck, 2007:725; Hendrie & Miller, 2012:24; SWOV, 2012:2–3; Wijnen, 2013:3). These costs are also considered in the 2016 study on the cost of crashes in South Africa (see

Labuschagne, 2016). These costs were also considered as a cost component for the purpose of assessing the cost of crashes in the current study.

*(j) Non-variable costs*

As indicated previously (see 3.3.2.7), some of the fixed costs that fall under this component are debatable as to whether or not they are strictly crash costs (Cillié & Freeman, 1977:21). For instance, it is not clear whether the cost of road policing and law enforcement is chargeable in part to road crashes, and if so, to what extent (Goosen & Kolman, 1982:41). On the one hand, it can be argued that the cost is incurred to promote the smooth functioning of the road system in general and that it is not related to road crashes. However, on the other hand, it is likely that road policing costs are influenced to some degree, at least, by crash occurrence (Cillié & Freeman, 1977:21; Goosen & Kolman, 1982:41) since law enforcement deployment is a responsive measure to alleviate occurrence of crashes in areas identified as hazardous locations.

Cillié and Freeman (1977:6) and Goosen and Kolman (1982:4) identified costs of processing and publishing road crash statistics, costs of policing and traffic control, costs incurred by vehicle manufacturers in designing vehicles of higher safety standards, and costs incurred by road authorities in designing and constructing safer roads as administrative costs categorised as 'non-variable crash costs' (see Table 3.13). Verburgh et al. (1985:39–40) identified road safety research and promotion costs and costs of processing and publishing traffic crash data as 'non-variable crash costs'. Glass and Hamilton (1987:39–40) also introduced crash prevention and data collection costs as sub-components of non-variable crash costs (see sub-section 3.3.2.7 and Table 3.13).

For the purpose of this study, only policing and traffic law enforcement costs, road safety research and promotion costs as well as the costs of processing and publishing road crash statistics, which Labuschagne (2016:39) refers to as road traffic crash management, were considered as non-variable costs.

In order to be able to calculate the total national road traffic crash costs, the number of road traffic crashes and casualties per severity are required. Therefore, road traffic crash severity is discussed in sections 4.5.1.2–4.5.1.4.

*4.5.1.2 Severity of road traffic crashes*

The number of road traffic crashes for 2017 for serious or major crashes, slight or minor crashes and property damage only crashes were estimated using the number of fatal crashes for 2017 provided by the RTMC. The following 2016 cost ratios of the different crash severity levels to fatal crashes calculated from the Cost of Crashes in South Africa report (Labuschagne, 2016:34) were used for this purpose:

- serious injuries crashes to fatal crashes was estimated at 7.1:1;
- slight injuries crashes to fatal crashes was estimated at 35.7:1; and
- property damage only crashes to fatal crashes was estimated at 112:1 (also see sub-section 5.2.1).

The number of road traffic crashes for 2017 for the different severity levels to the number of fatal crashes calculated using these ratios was used in the assessment of the cost of crashes in this study using the WtPA.

#### *4.5.1.3 Severity of road traffic injuries*

Labuschagne (2016:32) reports the following ratios in terms of the number of injuries to fatalities, which were derived from historical trends:

- the ratio of serious injuries to fatalities was estimated at 4.6:1;
- the ratio of minor injuries to fatalities was estimated at 14.9:1; and
- the ratio of property damage only (i.e. no human injuries) to fatalities was estimated at 105.2:1.

Using these ratios, absolute numbers of injuries for each one of the above road traffic injury severity levels were estimated using the 2017 fatality figure for use in this study. These figures were subsequently used in the valuation of the 2017 cost of road crashes using the WtPA.

#### *4.5.1.4 Calculation of the cost estimates per injury severity*

In line with Mohamed’s (2015:56) ratios, for the purpose of the current study, the calculation of the cost of serious injuries, minor injuries and property damage only were based on the following guidelines:

- the value of serious injury loss was estimated at 10.0% of the value of lost life;
- the value of a minor injury was estimated at 1.0% of the value of the lost life; and
- the value of property damage only resulting from a car crash was estimated at 0.1% of the value of the lost life.

The other road crash assessment approach used in the current study as shown in Figure 4.1 was the WtPA. The next section therefore explains how this approach was used in this study to calculate the VoSL, which in turn was used in the estimation of the cost of road crashes using the WtPA. In a way, this explains how the WtPA was applied empirically within the context of South Africa as envisaged by secondary objective 2 (see section 1.3.2 for secondary objectives). The road crash cost estimates obtained through this process are subsequently compared with the HCA-based estimates calculated by updating the 2016 cost of crash estimates using a 5.3% inflation rate to determine the comparability of cost estimates in line with secondary objective 3 (see section 1.3.2 for secondary objectives).

### 4.5.2 WtPA

Section 4.5.2.2 discusses the methodology that was employed to conduct an empirical investigation of the WtPA within the SA context. It particularly provides details in terms of the research design, study population and sample, data types, data collection instruments, reliability and validity and data collection and analysis.

#### *4.5.2.1 Research methodology used for the empirical investigation of the WtPA*

Secondary objective 2 of this study was to investigate empirically the WtPA in the SA context (see section 1.3.2 for the secondary objectives). The empirical investigation provided WtP-based road traffic crash cost estimates that could be compared with the cost estimates obtained by updating the 2016 HCA-based road crash cost estimates for inflation using the 2017 5.3% inflation rate. This was intended to determine the comparability of the cost estimates calculated using the two approaches as envisaged by secondary objective 3 (see section 1.3.2 for the secondary objectives). It however needs to be reiterated that the approach presented in this section is for illustrative purposes and therefore the resulting cost estimates do not reflect the real case scenario of road crash cost in South Africa.

Following is the research design that was followed to investigate the WtPA in the SA context empirically in line with the second secondary objective of this study.

#### *4.5.2.2 Research design of the empirical investigation of the WtPA*

The research design of this empirical investigation of the WtPA was a descriptive quantitative research. Since descriptive research studies are conducted to answer ‘who’, ‘what’, ‘when’, ‘where’ and ‘how’ questions, it therefore follows that the target beneficiaries of such studies already know or understand the underlying relationships of the problem area (Tustin et al., 2010:86). This study intended to answer the ‘what’ and ‘how’ questions because by achieving the:

- main objective, the study intended to propose a hybrid framework for use in the assessment of road traffic costs in South Africa therefore providing guidelines on *how* the assessment could be carried out;
- first secondary objective, the study would conceptualise a detailed literature review indicating approaches and components that good practice recommends for inclusion and consideration in road traffic cost assessment. The literature also provided

guidance on how these approaches and components are used in road traffic cost assessment studies. By achieving the first secondary objective, the study therefore answered two questions:

  - *Which* approaches and components should be considered in road crash cost assessment studies?
  - *How* are approaches and components used in good practice to assess road crash costs?

- second secondary objective of empirically investigating the WtPA in the SA context, the study demonstrates *how* the WtPA could be used in the SA context to assess the cost of road traffic crashes;
- third secondary objective by determining the comparability of the cost estimates obtained using the HCA and the WtPA, the study provided an answer to the questions:
  - *How* comparable are road crash cost estimates calculated using the HCA and the WtPA?
  - *What* is the difference between road crash costs calculated using the HCA and those obtained using the WtPA?
- fourth secondary objective by structuring the components of and the relationship between the HCA and the WtPA, the study answered these questions:
  - *What* is the difference between the HCA and the WtPA?
  - *What* is the relationship between the components of the HCA and the WtPA?
  - *How* can the HCA components complement those of the WtPA and vice-versa?

The contribution of this study to the body of knowledge on the assessment of road crash costs is twofold as –

- hardly any empirical study has been conducted within the SA context to investigate the applicability of the WtPA to assess the costs of road traffic crashes; and
- hardly any road traffic crash cost assessment study has been conducted in South Africa using both the HCA and the WtPA in one study therefore allowing for comparison of cost estimates calculated using these two approaches as this study envisaged.

Therefore, this study aimed to add to the body of knowledge by contributing knowledge addressing the two research gaps highlighted above. Yusoff et al. (2013:14) outline the research design and therefore the process of calculating the VoSL followed in this study in seven stages as depicted in Figure 4.2.


**Figure 4.2: Value of statistical life study stages**

*Source: Adapted from Yusoff et al. (2013:14)*

The sections below discuss five aspects of the research design of this study, namely population and sample of respondents, data types, data collection instruments, reliability and validity, data collection and analysis.

*(a) Population and sample*

For the purpose of this study, the population consisted of all employees of the DoT, C-BRTA, RSR, RAF, RTIA, RTMC and SANRAL. Babbie (2011:207) asserts that sometimes it is appropriate to select a sample on the basis of knowledge of a population, its elements, and the purpose of the study, and this type of sampling is called ‘purposive sampling’. It is against this background that, for the purpose of this study, a purposive sample (N=273 respondents) was drawn from this population, with a particular focus on employees at supervisory and management levels. Employees at these levels were preferred for the purpose of this study because they have an in-depth understanding of the transport environment Babbie (2011:207). They therefore were considered able to provide meaningful and appropriate responses to the contingent valuation and SP questions in the WtP survey questionnaires that were administered to collect primary data for this study.

The sample was therefore stratified by level of employment at work in terms of whether respondents were at supervisory or management level. Incorporating stratified sampling in the purposive sampling was intended to ensure representativeness of the sample across the different respondents’ employment levels at their places of employment, namely the DoT, C-BRTA, RSR, RAF, RTIA, RTMC and SANRAL.

*(b) Data types*

For the purpose of this study, primary data were collected on respondents’ demographic characteristics as well as their responses to contingent valuation and SP questions prompting them to indicate their willingness to pay to reduce their risk of road crash injury. Primary sources, which are the sample described in sub-section (a) above, are original research or raw data that have not been filtered or interpreted by a second party therefore making the data the most authoritative (Cooper & Schindler, 2014:96; Tustin, Ligthelm, Martins & Van Wyk, 2010:89).

*(c) Data collection instruments*

Two WtP survey instruments were developed for the purpose of this study. The first WtP survey instrument was developed in three phases. Firstly, WtP literature was consulted to determine the general structure of the instrument. Then, research experts and the Research Ethics Committee of Unisa reviewed the instrument for content validity, and finally the instrument was pilot tested on 11 respondents. In line with Le et al. (2011:3–10) and Abdallah et al. (2016:13), the WtP questionnaire consists of three parts:

> *Part 1:* respondents’ characteristics or profile: demographic profiles, travel behaviour and historical road traffic crash involvement of respondents;

*Part 2:* contingent valuation questions; and

*Part 3:* a stated preference question.

In keeping with Haddak et al. (2014:n.p.), the demographic and travel behaviour information that respondents were required to provide included:

- socio-economic characteristics in terms of age, gender, education, income, car ownership and purpose of travel to make the assessment of their socioeconomic status possible. Designation at work was used as a stratification variable;
- personal experience of traffic crashes where the study distinguished direct experiences, that is where respondents were personally involved in a road crash, from indirect ones where family members or their close relatives were involved;
- use of transportation means, which enabled the description of transport practices, including mobility issues, the mode of transport most frequently used and time spent travelling by respondents;
- perception of self and family risk of injury in road crashes. In order to identify respondents that understood the risk of motor vehicle accidents, the WtP questionnaire also had a question prompting respondents to choose between two routes of different risk levels. Only WtP responses of respondents who chose a less risky route were used to calculate the VoSL for use in calculating the cost of crashes for comparison with the RTMC cost estimates updated for inflation in Chapter 5. This was intended to achieve the third secondary objective of this study by determining the comparability of the cost estimates calculated using the HCA and those obtained using the WtPA.
- willingness to pay of respondents:
    - *contingent valuation* (CV) – its purpose was to establish a fictional scenario, however realistic and intelligible, from which respondents were called to reason and express how much they would be willing to pay, given ten options, to reduce their risk of experiencing injury due to a road crash; and
    - *stated preference valuation* – SP questions provided for a more sophisticated method for obtaining individuals' valuations by presenting respondents with nine pairs of hypothetical but realistic scenarios, where they had to trade off three different travel attributes, namely travel time, cost and number of fatalities in deciding which alternative to choose (Abdallah et al., 2016:13; Le et al., 2011:3).

The use of both the CV and SP techniques in the WtP approach is intended to increase the certainty of obtaining reliable results and enable comparison of the road crash values derived from both methods (Abdallah et al., 2016:12). The results are then used to develop choice models that are used to estimate road crash cost estimates. The basic aim of this approach is to derive monetary values of safety that reflect the preferences and wishes of those members of the public who would be affected by safety investment decisions (O'Reilly et al., 1994:47).

The European Transport Safety Council (2007:7) recommends that studies should be conducted to determine which variables are the strongest predictors of social disparities in road crash risk: education, income, designation at work, historical involvement in road crashes by self or family, and gender. It is against this background that Haddak (2016:298–299), Haddak et al. (2014:n.p.) and Yusoff et al. (2013:26–29) report that information on these factors is necessary to serve as explanatory variables for use in correlations and regression analyses. In line with the analysis of Adballah et al. (2016:14–15), this information is also collected for use to determine WtP in relation to these different demographic characteristics of respondents.

Two WtPAs were used to calculate the VoSL for use in the assessment of the 2017 motor vehicle crash cost estimates in South Africa, namely the CVM and the SPM. These two methods are discussed briefly below.

The contingent valuation (CV) questions simply ask respondents to state how much they are willing to pay for a reduction in the risk of getting killed in a road crash (Le et al., 2011:3) or for their marginal value of safety (Maier et al., 1989:181). The questions used in this study were sub-divided into two parts. These two parts are shown in Table 4.4.

**Table 4.4: Contingent valuation question – Parts 1 and 2**

**SECTION B – ROAD CRASH CONTINGENT VALUATION**

**2 Road Crash Contingent Valuation**

**The next section is to learn about what you think about risks when travelling on the road.**

2.1 Imagine that you have decided to walk to a friend's house. There are two different possible routes, both of which involve crossing busy roads.

Which of the following roads is safer to cross? (Please tick the applicable box.)

| | |
|---|---|
| Crossing Road A has a risk of 20 in 100 000 that you will be injured in an accident. | |
| Crossing Road B has a risk of 40 in 100 000 that you will be injured in an accident. | |

2.2 Now imagine that you have to make a journey every weekday of the year for some reason.

2.2.1 Suppose the government has a programme to improve the safety of your daily journey, which would reduce the annual risk of being injured to 161 people per million population. That is, there would be approximately 30% reduction in the risk of being injured.

How much are you willing to pay per day for the reduction in this risk (in South African Rand)? (Please tick the applicable option.)

| Per day | 7.40 | 14.79 | 22.19 | 29.59 | 36.99 | 44.38 | 51.78 | 59.18 | 66.58 | More than 66.58 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

2.2.2 Suppose the government has a programme to improve the safety of your daily journey that would reduce the annual risk of being injured to 115 people per million population. That is, there would be approximately 50% reduction in the risk of being injured.

How much are you willing to pay daily for the reduction in this risk (in South African rand)? (Please tick the applicable option.)

| Per day | 7.40 | 14.79 | 22.19 | 29.59 | 36.99 | 44.38 | 51.78 | 59.18 | 66.58 | More than 66.58 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

The questions in Table 4.4 explored how much the respondents were willing to pay per day to reduce the risk of being killed in a road accident. A figure of an average of 230 used in determining the 161 ([100% - 30%] x 230) and 115 (50% x 230) used in the CV questions above was derived from the RTMC accident records over a five-year period from 2012 to 2016 (see RTMC, 2013; 2014; 2015; 2016; 2017). The first question required participants to indicate how much they were willing to pay for a 30% reduction in their risk of injury in road accidents whereas the second question prompted the same respondents to indicate how much they were willing to pay for a 50% reduction in their risk of injury. The reason for presenting two different risk reduction scenarios was to investigate whether this would result in different WtP values, i.e. to check whether respondents' willingness to pay was sensitive to differences in risk probabilities.

In order to help the respondents to choose their own alternative if the cost of using a particular route was expressed as a per-day amount, the average e-toll cost[42] of one gantry of the Gauteng Freeway Improvement Project (GFIP) immediately after the OR Tambo International Airport on the R21 towards Pretoria, namely Weaver (R21-2) or gantry number 44, was used as the base cost. This base cost was found to be R7.40 per day, which is the first figure for each one of the options in the questions above. In line with practices in previous studies (see Adballah et al., 2016; Le et al., 2011; Maier et al., 1989) conducted internationally, the subsequent cost figures were calculated by adding R7.40 to the previous figure, for example, 7.40+7.40=14.80. Responses to these questions were used to calculate the VoSL, which was used to assess 2017 road crash cost estimates for South Africa.

[42] The average e-toll cost was calculated by adding the cost for each motor vehicle class together and dividing the sum by the number of motor vehicle classes, i.e. 4.

SP questions provide for a more sophisticated method for obtaining individuals' valuations by presenting respondents with pairs of hypothetical but realistic scenarios, where they trade off different travel attributes such as travel time, cost and number of casualty crashes in deciding which alternative to choose (Le et al., 2011:3). For the SPM, a route choice experiment was designed. It is known that there is a trade-off between complexity and the number of SP experiments. Following the same rationale as Abdallah et al. (2016:16), two experiments of nine scenarios were presented to each respondent.

The sample for the experiments consisted of a sub-sample of the original sample, namely 111 respondents who had the same demographic composition as the original sample.

The table below provides the original sample composition and the sub-sample for the SP experiments.

**Table 4.5: The original sample composition and the sub-sample for the stated preference experiments**

| Demographic profile | Characteristics | Main sample | Sub-sample |
|---|---|---|---|
| Position at work | Assistant director | 7.8 | 5.4 |
| | Chief director, executive manager | 8.4 | 11.7 |
| | Deputy Director | 16.2 | 18.0 |
| | Deputy director-general, senior executive manager, chief operations officer | 7.8 | 5.4 |
| | Director-general, chief executive officer (CEO) | 4.5 | 4.5 |
| | Director, senior manager | 27.4 | 23.4 |
| | Other | 25.1 | 28.8 |
| | Senior admin clerk | 2.8 | 2.7 |
| Gender | Female | 42.5 | 39.6 |
| | Male | 57.5 | 60.4 |
| Age | 25–34 | 8.4 | 6.3 |
| | 35–44 | 46.9 | 41.4 |
| | 45–54 | 34.1 | 38.7 |
| | 55–64 | 10.6 | 13.5 |
| Education | Below Grade 12 | 1.1 | 0.0 |
| | Degree | 45.3 | 39.6 |
| | Diploma | 10.1 | 9.9 |
| | Doctoral degree | 2.2 | 0.9 |
| | Grade 12 or National Certificate | 6.1 | 8.1 |

| Demographic profile | Characteristics | Main sample | Sub-sample |
|---|---|---|---|
| | Higher certificate | 4.5 | 5.4 |
| | Master's degree | 30.7 | 36.0 |
| Car ownership | More than one car or vehicle | 57.0 | 64.0 |
| | No car or vehicle | 3.9 | 1.8 |
| | One car or vehicle | 39.1 | 34,2 |
| Income | Below 10 000 | 0.0 | 0.9 |
| | 10 000–20 000 | 6.1 | 7.2 |
| | 20 001–30 000 | 6.7 | 11.7 |
| | 30 001–40 000 | 15.6 | 9.9 |
| | 40 001–50 000 | 12.3 | 11.7 |
| | 50 001–60 000 | 11.2 | 9.0 |
| | 60 001–70 000 | 9.5 | 12.6 |
| | 70 001–80 000 | 8.9 | 7.2 |
| | More than 80 000 | 29.6 | 29.7 |

As indicated above, the follow-up questionnaire to collect data for use in the SPM had three variables of interest: trip cost, travel time and number of fatalities per year. The number of scenarios required was 27 based on each variable having three levels as shown in Table 5.10 (see section 5.2.2.6). In order for the designs to be robust it was important that they contained a good range of trade-offs and that the implied boundary values covered a good range as well (Abdallah et al., 2016:16). A boundary value is the value of which the utility between two modes is exactly the same, and it can be calculated for each scenario presented. Furthermore, it is important to ensure that the variables are combined such that there are low correlations between them, otherwise multi-collinearity results leading to estimation problems (Abdallah et al., 2016:15). According to Abdallah et al. (2016:16), the standard procedure for determining how the different variables are combined is to use 'orthogonal' designs. An orthogonal design is a design where the correlation between variables is zero (Bennett, 2011:280).

The boundary values used in the designs were based on the 2017 costs, number of fatalities and estimated travel time for the three routes considered, namely e-tolled portions of N1 (Johannesburg Metropolitan Municipality), N3 (Ekurhuleni Metropolitan Municipality) and N12 (Ekurhuleni Metropolitan Municipality). The estimated time levels were selected as realistic as possible in terms of respondents' travel experiences. The journey time of interest was the in-vehicle time, which was the overall door-to-door journey time minus any wait or walk time.

The trip costs were calculated based on real e-toll costs respondents were required to pay as they travelled on the selected road network. The number of fatalities per year was the exact number of fatalities the two metropolitan municipalities recorded for the selected routes for the year 2017 as provided by Sintel, a private company the two municipalities contracted to record their road crash statistics. However, in line with previous studies, the way in which the different levels of each of the three variables were combined was carefully considered to ensure that the variables were combined such that there were low correlations between them to avoid multi-collinearity. Given that there were three variables of interest, namely travel time, trip cost, and the number of fatalities, the number of scenarios that were needed was 27 based on each variable having three levels as shown in Table 5.10.

*(d) Reliability and validity*

Reliability is a matter of whether a particular technique, applied repeatedly to the same object, yields the same result each time (Babbie, 2011:157). Reliability occurs when a test measures the same thing more than once and results in the same outcomes (Van Zyl, 2014:115). Reliability of a research instrument or questionnaire is therefore that quality of a measurement method that suggests that the same data would have been collected each time in repeated observations of the same phenomenon (Babbie, 2011:157). Therefore, reliability is fundamentally concerned with issues of consistency of measure (Bryman, 2008:149).

One of the techniques used for cross-checking the reliability of the measures is the use of established measures or instruments (Babbie, 2011:1590). It is against this background that, for WtP data collection purposes, questionnaires that were used for similar studies globally were adapted for use in this study (see Table 1.2 above for previous studies from which WtP questions were adapted for use in the survey questionnaire used for the current study). Furthermore, prior to administration, the WtP questionnaire (see Annexure C for the questionnaire) was piloted to 11 employees of the RTMC to check whether there are any items that were ambiguous, so that any ambiguity could be addressed before the actual administration of the questionnaire. Internal consistency (Cronbach's alpha) measurement of reliability did not apply in this study as very specific risk- and scenario-based methods were used and no constructs measured on Likert-type response scales were included in the questionnaires.

Therefore, the WtP survey questionnaires used in the studies in Table 4.6 were adapted in line with most of the above recommendations for use in the current study to collect data on respondents' demographic characteristics, travel behaviour as well as their willingness to pay to reduce their risk of road traffic crash injury (see Annexures C and D for the adapted WtP questionnaires):

**Table 4.6: Previous studies that used the WtPA**

| Author(s) | Year of publication | Page(s) | Country |
|---|---|---|---|
| Abdallah et al. | 2016 | 14 | Egypt |
| Muller and Reutzel | 1984 | 812 | United States |
| Le et al. | 2011 | 4–5 & 9 | Singapore |
| Haddak | 2016 | 296, 298 & 299 | France |
| Haddak et al. | 2014 | No pages | France |

Furthermore, Cawley's (2006) recommendations were also followed to maximise the reliability of CV road traffic crash cost estimates calculated in this study (see section 3.2.1 for the recommendations).

'Validity' refers to the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration or a measure that accurately reflects the concept it is intended to measure (Babbie, 2011:158 & 160; Bryman, 2008:151; Van Zyl, 2014:123). In other words, in the case of this study, the validity of the WtP questionnaire meant that the instrument measured what it was intended to measure, namely the willingness to pay for the reduction of risk of injury on the road. The use of items adapted from questionnaires that were used in similar studies conducted globally, such as those listed in Table 4.6 above, ensured both face and content validity of the data collection instrument that was employed for the WtPA purposes. Face validity is the quality of an indicator that makes it seem a reasonable measure of some variable or an indicator that 'makes sense' as a measure of a construct in the judgment of others, especially those in the scientific community (Babbie, 2011:160; Neuman, 2014:6). In this case, it was willingness to pay for the reduction of risk of injury by road users as identified by acknowledged research in this environment. On the other hand, content validity is the degree to which a measure covers the range of meanings included within a concept (Babbie, 2011:161; Neuman, 2014:3). Adapting approaches and instruments used in previous similar studies ensured that cost components and questionnaire items guaranteed content validity as well (see Table 4.6 for studies from which questions were adapted).

The above measures were intended to ensure that the methodology used for this study was both valid (measuring what it was intended to measure) and reliable (yielding a given measurement dependably) (Babbie, 2011:162).

As depicted in Figure 4.2, the process of the valuation was started with the design of a survey instrument. i.e. the WtP survey questionnaire. The questionnaire was formulated to capture relevant data that could be used to formulate the VoSL. The questionnaire was loaded onto SurveyMonkey for online data collection purposes. The online survey began with a pilot study on 11 respondents within the RTMC to test the understanding of questionnaire content by potential respondents, including the reliability and robustness of valuation questions in meeting stated objectives of this study. Corrections were made on the questionnaire to alleviate identified errors and misunderstandings among respondents. The main study was conducted from 05 October to 06 November 2017. A total of 273 respondents from DoT, C-BRTA, RAF, RSR, RTIA, RTMC and SANRAL were targeted. The process reached its final stage with the exporting of data from SurveyMonkey to MS Excel and then SPSS (Statistical Package for the Social Sciences) for statistical analysis and estimation of the VoSL and use thereof in the assessment of the cost of crashes using the 2017 crash data. In part, this report is a culmination of this process. Figure 4.2 summarises the stages involved in the calculation of the VoSL for the purpose of this study. It needs to be emphasised that for the purpose of this study, the formula of Yusoff et al. (2013) was used.

*(e) Data collection and analysis*

Letters were forwarded to Chief Executive Officers (CEOs) of C-BRTA, RAF, RSR, RTIA, RTMC and SANRAL as well as the director-general of the DoT on 23 June 2017 requesting permission to administer the survey questionnaires to employees of these institutions at supervisory, management and executive level (see Appendix F). Written permission from the CEOs was received from C-BRTA, RAF, RSR and RTIA. Each one of these institutions appointed a dedicated person to liaise with both the researcher and employees regarding the surveys. For the other institutions, the researcher liaised directly with respondents.

SurveyMonkey questionnaire links were subsequently forwarded directly to the target employees for them to complete the surveys online. The two questionnaires were administered by means of two separate 15- to 20-minute online surveys in line with good practice (Sadri, MacKeigan, Leiter & Einarson, 2005:1217). As indicated in sub-section (c) in the previous page, respondents to the second questionnaire were a sub-sample of the sample that answered the first questionnaire. This is evident from Table 4.4, which shows that the main sample and the sub-sample had similar demographic characteristics.

After the administration of the WtP survey questionnaire (see Annexure C for the questionnaire) was completed, the data was exported to Microsoft Excel and further exported to SPSS for analysis. The data collected was intended for use to investigate empirically the applicability of the WtPA within the SA context in order to achieve the second secondary objective of this study. Furthermore, the third secondary objective of this study was to determine the comparability of the cost estimates obtained using the HCA and those calculated using the WtPA. Therefore, in order for this comparison to be possible, there was a need to use the data collected through the two WtP survey questionnaires to determine the cost of road traffic crashes as well.

Below is a brief description of the names of the statistical outputs that were generated through the analysis in order to be able to calculate the costs of road traffic crashes using the WtPA. The names of the statistical outputs are diagrammatically summarised in Figure 4.3.

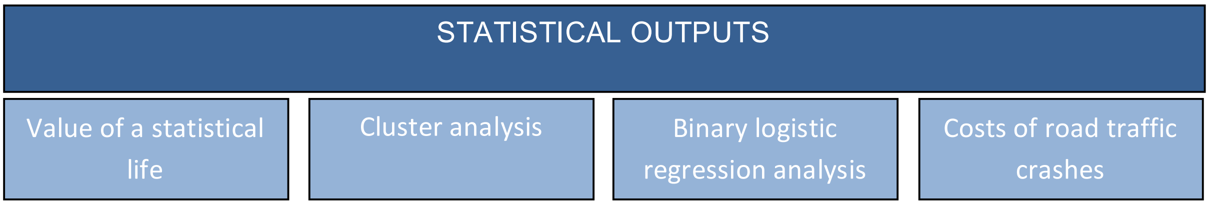


**Figure 4.3: Names of the statistical outputs generated to assess the cost of road traffic crashes using the WtPA**

Figure 4.3 shows the names of the statistical outputs that were generated to be able to assess the costs of road traffic crashes using the WtPA; namely the VoSL, cluster analysis, binary logistic regression analysis as well the costs of road traffic crashes themselves. These concepts are briefly discussed below.

- **Value of a statistical life**

As indicated in the preceding chapters, it is critical to emphasise that in view of the fact that policy analysis is forward-looking, it is necessary to value the benefit of reducing further risk to life rather than valuing lives lost (see section 2.3.2). This is achievable since everyday people make decisions that trade off risks to their lives against other benefits and in doing so, exhibit a willingness to pay (WtP) for risk reduction. Information on this WtP enables policymakers to estimate the value of preventing a fatality (VPF), commonly known as the value of a statistical life (VoSL) (Tooth, 2010:1). Mohamed (2015:47) refers to a VoSL as the value of preventing statistical fatality (VPSF).

The VoSL is of major importance to cost–benefit assessment of road infrastructure investments, road maintenance planning, and road traffic control and safety decisions, such as limitation of speed; thus ensuring efficient allocation of resources (Bahamonde-Birke et al., 2015:488; Hultkrantz, Lindberg & Andersson, 2005:n.p.). More direct estimates of VoSL are obtained from studies using a WtPA based on peoples' stated preferences (i.e. surveys) or revealed preferences (i.e. observed behaviour) on WtP for reduced risks (Tooth, 2010:1).

The fundamental principle for valuing the benefits of government policies is society's willingness to pay for the policy effects that reduce fatal injury risks (such as road safety programmes). The policy impact to be valued is the expected number of lives that will be saved by the policy (Kniesner et al., 2014:188). Viscusi (2015:227) and Lee and Taylor (2017:1) assert that the value of a statistical life is the most influential single parameter used in calculating the benefits of governmental regulations. As indicated in the preceding chapters, in order to value the benefits of government policies and regulations with the purpose of reducing mortality risks, monetised values of safety are required to be able to compare the benefits with the economic costs. According to Svensson (2009:2) and Jokanović and Kamel (2014:153), the monetised benefit of reduced mortality risk is captured in the concept of a VoSL, which they define as the willingness to pay (WtP) for a small risk reduction for each individual in society that overall is expected to prevent one premature death.

VoSL is a concept which was born out of political interest, but later started serving as a policy instrument (Majumder & Madheswaran, 2016:2). In support of this assertion, Moran and Monje (2016:2) also indicate that the benefit of preventing a fatality is measured by what is conventionally called the VoSL, defined as the additional cost that individuals would be willing to bear for improvements in safety (that is, reductions in risks) that would reduce the expected number of fatalities by one.

The Organisation for Economic Co-operation and Development (OECD) (2012:4), Shanmugam (2013:2) and Ballavance, Dionne and Lebeau (2009:444) assert that VoSL is a very sensitive, controversial and contentious topic in economic research because in the minds of many, 'you can't put a price on life', but one which is essential to the optimisation of governmental decisions. Similarly, Social Value UK (2016:2) report that:

> Perhaps the most controversial aspect of valuation is the attempt to ascribe a financial value to a human life. Understandably, for ethical, religious or philosophical reasons, many people oppose the valuation of something commonly perceived as priceless, and argue that no monetary figure could possibly compensate entirely for the loss of life.

In the same vein, Majumder and Madheswaran (2017:110) assert that as much as the VoSL is one of the most debatable areas in economics, it is frequently required for use as a policy instrument for evaluation of various safety, health and environmental regulations. Policymakers have to undertake the difficult task of assigning monetary value to the reduction of various health and mortality risks while analysing safety policies (Majumder & Madheswaran, 2017:110). Viscusi and Aldy (2003:5), and Madheswaran (2004:3) assert that VoSL estimates provide governments with a reference point for assessing the benefit of risk reduction efforts. It is therefore the most prevalent benefit assessment approach used by state agencies when valuing changes in risk (Shanmugam, 2013:1). In defence of the importance of the VoSL, the OECD (Shanmugam, 2013:1) makes a strong case by emphasising that as a rule, the utility associated with reducing a risk must compensate for the disutility associated with the cost of reducing the risk, and in performing this type of cost–benefit analysis, a monetary value for human life could prove invaluable.

The VoSL is a well-established concept in the economics literature (see Shanmugam, 2013) based on econometric estimates of wage-fatality risk trade-offs in the labour market (see Kniesner, Viscusi & Woock, 2011) and it provides the yardstick that countries require to use in valuing fatality risks reduced by regulatory programmes (Kniesner, Viscusi & Woock, 2011:n.p.). According to Yusoff et al. (2013:7), the VoSL in the road traffic context is estimated by examining the relationship between an individual's willingness to pay for a marginal reduction of the risk of being killed in a road traffic crash and the reduction or change of that fatality risk. Yusoff et al. (2013:8) and OECD (2012:8) further assert that empirically, the formula used in calculating the VoSL is as follows:

$$VoSL = WtP/\Delta p$$

where:

WtP is the amount (in rand) that individuals are willing pay for a small change ($\Delta p$) in the risk of a fatal outcome; and

$\Delta p$ represents risk change.

Then WtP/$\Delta p$ is estimated to equal the amount individuals will pay to prevent one death.

Mohamed (2015:55) estimates the marginal rate of substitution of wealth by the risks of life or what is known as the VoSL, according to the visions of the respondents to the amounts they are willing to pay to reduce risks, which can be measured by dividing the WtP on the change in risks of death probability, i.e. –

> the marginal rate of substitution = the WtP or the change in the risks of death probability.

Mohamed (2015:55) defines the VoSL as the change in the wealth to the change in the risk.

In keeping with Yusoff et al. ( 2013:8), Bahamonde-Birke et al. (2015:492) present the VoSL as follows:

> VoSL = $\left(\frac{1}{N}\right)\sum_{i=1}^{N} WtPi$ .
>
> where $WtP_i$ stands for the WtP of an individual i, and N for the size of the population.

This formula is similar to the one used by Hensher, Rose, De Dios Ortúzar and Rizzi (2011:73) as well as Maier et al. (1989:181) who denote the i-th individual's marginal rate of substitution by $MRS_i$. Maier et al. (1989:181) further assert that in a population of N, individuals' avoidance of one statistical death per time period requires a risk reduction of 1/N. VoSL is the marginal rate of substitution between income and risk of death for a person i ($MRS_i$) plus a covariance term that accounts for possible correlation between WtP and reduced risk (Rizzi & De Dios Ortúzar, 2006a:75; 2006b:473). The amount people are willing to pay for this reduction of risk in that time period is therefore $\sum_{i}^{N} MRSi \left(\frac{1}{N}\right)$ or simply the average marginal rate of substitution (Hensher et al., 2011:73; Maier et al., 1989:181).

In order to be able to determine how different characteristics of the respondents influence their willingness to pay to reduce the risk of road traffic injury, cluster analysis was performed to classify respondents based on observed characteristics into homogeneous groups. This process of finding similarities between data according to the characteristics found in the data and grouping similar data objects (i.e. respondents in this case) into clusters is called cluster analysis (Han, Kamber and Pei, 2011:n.p.). The following section briefly discusses how the cluster analysis technique was applied in this study.

- **Cluster analysis**

The purpose of cluster analysis is to maximise heterogeneity between segments (Hair, Black, Babin & Anderson, 2010:508; Zikmund, Babin, Carr & Griffin, 2013:597). According to Rundle-Thiele, Kubacki, Tkaczynski and Parkinson (2015:526), two-step cluster analysis allows the simultaneous analysis of both categorical and continuous data, which was highly appropriate in this study where categorical and (self-reported) behavioural data were analysed at the same time. It is against this background that the two-step cluster analysis technique was performed in this study to determine whether distinguishable respondent profiles exist that represent their demographic information and explain their WtP behaviour. In particular, the characteristics and demographic information considered were: age, gender, education level, income level, involvement in road accident in the past, main purpose of travel, car or vehicle ownership, hours travelled per day, level of anxiety or worry about self or family member getting involved in a road accident, and mode of transportation.

The next section discusses how binary logistic regression analysis was applied in this study to model SP data.

- **Binary logistic regression analysis to model stated preference outcome**

Stated preference (SP) or the choice experiment method is one of the non-market methods used in economic valuation in transportation, economics and marketing using multinomial logistic regression analysis; amongst others (Vojáček & Pecáková; 2010:36). The study introduced the application of logistic regression analysis in modelling the SP outcomes in line with the application of this method in the international research reviewed. The variables included the three scenario variables namely cost, fatalities, and time in making a choice between two scenarios, i.e. Route A and Route B.

SP experiments are usually analysed by using discrete choice models. The main objective of discrete choice modelling is to analyse the individual's choice in relation to the characteristics (attributes) of a product, for example choice of a route or road network in relation to toll cost, travel time and number of fatalities as was the case in this study (see Vojáček & Pecáková, 2010:37). According to Vojáček and Pecáková (2010:37), a decision-maker chooses among a set of *J* options. The dependent variable *Y*, a discrete variable with a countable number of *J* values, represents the outcome of the decision. In the case of the SP experiments used in this study, *J* equals two route options, and the dependent variable *Y* is route choice or willingness to pay. The goal of the analysis is to understand which of the three variables considered in this study influence route choice (i.e. cost, travel time, and fatalities) and to what extent these variables influence route choice and therefore willingness to pay. The utility of the alternative *j* for some decision-maker can be expressed as a linear combination of the observed (non-random) factors (see Vojáček & Pecáková, 2010).

The most widely used discrete choice model, is a multinomial logit (MNL) model. The MNL model seems to be quite robust with respect to deviations of the random component distribution from the model (Vojáček & Pecáková, 2010). There are three considerable advantages to the MNL model: computational ease, easy-to-obtain probability expression of an individual selecting a given alternative, and straightforward determination and maximisation of its likelihood (which reduces possible model estimation difficulties) (Vojáček & Pecáková, 2010:37).

The discrete choice data for this study were gathered using the SPM, a choice experiment method, which is one of the choice modelling approaches that are consistent with economic theory (Vojáček & Pecáková, 2010:43). The results for both the MNL model and the binary logit model were exactly the same in the case of this study since the experiment only involved two choices (J = 2). Only the results of the binary logistic model are presented here. In order to assess the viability of the model, amongst others, the following tests were considered in this study as recommended by Meyers, Gamst and Guarino (2013:541):

- -2 log likelihood ratio (see Meyers et al., 2013; Darlington & Hayes, 2017);
- omnibus chi-square (see Meyers et al., 2013; Darlington & Hayes, 2017);
- pseudo $R^2$ (see Meyers et al., 2013; Darlington & Hayes, 2017); and
- Wald test of significant coefficients (see Meyers et al., 2013; Darlington & Hayes, 2017).

All the preceding statistical outputs are a means to an end, and in the current study, this end was the assessment of the costs of road traffic crashes in South Africa. Therefore, the ultimate statistical outputs are estimates of the costs of road traffic crashes in South Africa. The next section briefly explains how these cost estimates were calculated in the current study.

- **Costs of road traffic crashes**

The second secondary objective of this study (see 1.3.2) aimed at investigating the WtPA in the SA context. This investigation concluded by applying the WtPA to assess the costs of road traffic crashes in South Africa. As envisaged by the third secondary objective of this study (see 1.3.2), the cost estimates obtained using the WtPA were used to determine the comparability of the SA HCA cost estimates and those calculated using the WtPA. Therefore, for this purpose, two sets of road traffic crash estimates were assessed using the CVM and the SPM.

## 4.6 CONCLUSION

The overall objective of this study was to propose a hybrid framework for the assessment of road traffic crashes in South Africa (see section 1.3.2). This was realised by achieving four secondary objectives (see section 1.3.2 for the objectives). Therefore, this chapter partially reported on the analyses of international practice on the assessment of road traffic crashes in Chapter 2 compared to the SA practices summarised in the literature review reflected in

Chapter 3. This analysis helped to identify approaches and components commonly used internationally and to compare these with those common across all eight SA road crash assessment studies reviewed for the purpose of this study (see section 3.3.2). By analysing approaches and components considered in SA studies in comparison to those used internationally, we were able to identify practices that could be replicated to enhance the approaches used in South Africa. This enabled the structuring of the components of and the relationship between the HCA and the WtPA as envisaged by the fourth secondary objective (see section 1.3.2 for secondary objectives).

From the reviewed international literature, this chapter identified common cost components that could be included in the hybrid framework for assessing the cost of road traffic crashes in South Africa. In addition, common cost components that were used in all eight SA studies were identified and compared with those common in the countries considered to get an international perspective. This comparison was intended to identify gaps in the SA approach, and to address the gaps using lessons from international practice. Through this process, the fourth secondary objective of this study was achieved by structuring the cost components of and the relationship between the HCA and the WtPA.

The chapter also outlined the manner in which the road crash cost estimates were assessed using the two approaches of the WtPA, namely the CVM and the SPM. Cost estimates calculated using this method were intended for comparison with the inflation-adjusted HCA-based cost estimates as envisaged by the current study.

The next chapter reflects how the crash cost assessment approaches and methods explained in this chapter were applied. Firstly, the chapter presents and discusses the updated 2016 HCA-based cost estimates. Secondly, the chapter provides results of the two methods of the WtPA specified above.

# CHAPTER 5:
# ASSESSMENT OF ROAD TRAFFIC CRASH COST IN THE SOUTH AFRICAN CONTEXT

## 5.1 INTRODUCTION

- The fourth secondary objective of this study was to determine the comparability of the cost estimates of the HCA and those of the WtPA (see section 1.3.2). There was therefore a need to calculate 2017 cost estimates for both methods. In order to obtain the WtPA cost estimates, there was also a need to investigate the applicability of the approach in the SA context empirically as envisaged by the second secondary objective (see section 1.3.2). This investigation was concluded by calculating the costs of road traffic crashes using this approach. It however needs to be emphasised that the cost estimates calculated in this study cannot be generalised for the South African population since they were only calculated to illustrate the application of this approach.

The aim of this chapter is therefore to report on the assessment of the costs of road traffic crashes using the two identified approaches, namely:

- **The HCA** through which cost estimates were assessed by adjusting the 2016 cost estimates for inflation using a 5.3% inflation to obtain 2017 crash cost estimates for South Africa; and
- **The WtPA** using CV and SP data collected through a WtP survey questionnaire, which was conducted in October and November 2017 and May and June 2018 respectively.

The chapter outline is depicted by the flow diagram in Figure 5.1.

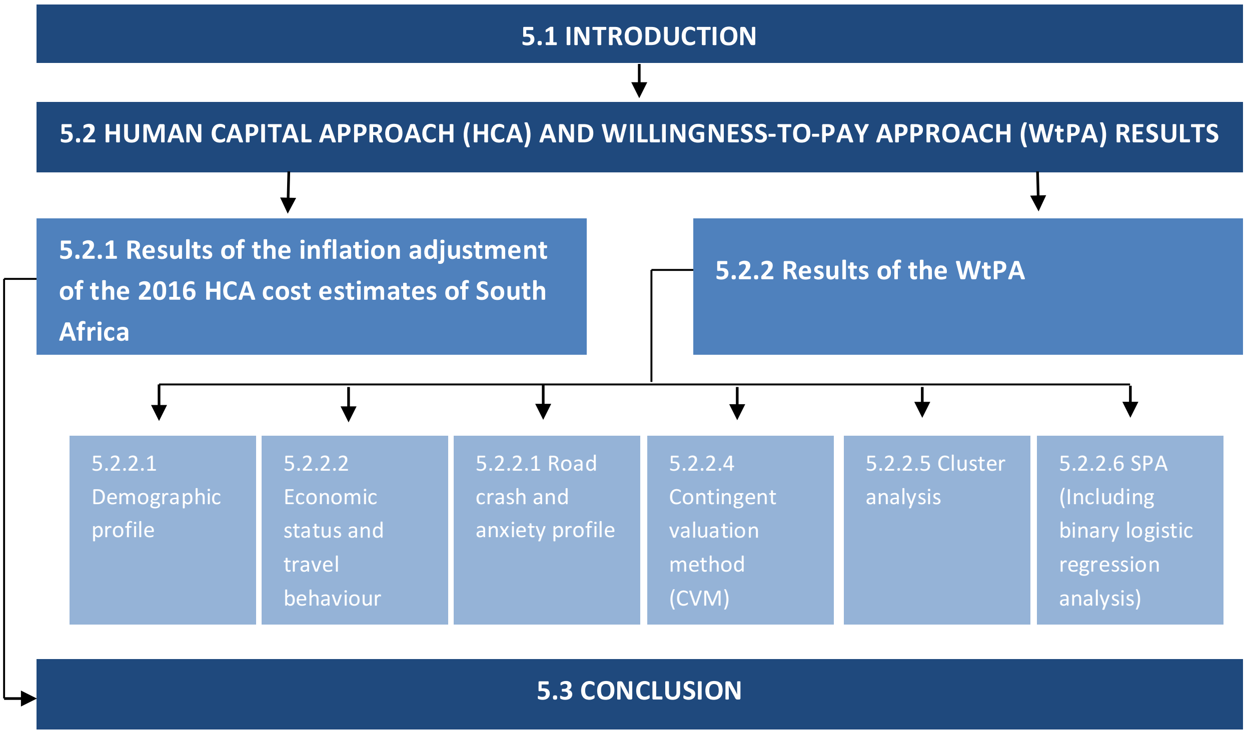


**Figure 5.1: Flow diagram of Chapter 5**

As Figure 5.1 shows, Chapter 5 starts with an introduction identifying the objectives of the study. The introduction also explains what the chapter in its entirety entails. The figure indicates that the introduction is followed by a detailed presentation of the results of the two approaches identified for use in this study. Firstly, the results of the inflation-adjusted 2017 road crash cost estimates are presented followed by a detailed discussion of the results of the WtPA. The WtP results will start with respondents' characteristics in terms of their demographic profile, economic status and travel behaviour as well as road crash and anxiety profile in sections 5.2.2.1 to 5.2.2.3. In section 5.2.2.4, results of the CVM are presented followed by a cluster analysis of respondents' characteristics, which is reflected in section 5.2.2.5 to categorise respondents into groups of similar profiles. This assisted in establishing which characteristics influenced respondents' willingness to pay for a reduction in the risk of injury in road traffic crashes. In section 5.2.2.6, results of the SPM including the statistical outputs of the binary logistic regression analysis are presented. Section 5.2.2.7 concludes the chapter by briefly summarising the main findings of the study.

Results of the two approaches are provided in the next sub-sections.

## 5.2 HCA AND THE WTPA RESULTS

This section presents the results of the two approaches identified through a review of international literature in Chapter 2 for application in the assessment of road traffic crashes in South Africa. Firstly, it presents the 5.3% (Stats SA, 2018b:5) inflation-adjusted 2017 HCA road traffic cost estimates results. Secondly, it discusses the demographic profile and travel behaviour and characteristics of the respondents together with the results of the two methods of the WtPA, namely the CVM and the SPM. Cost estimates determined using the HCA and the WtPA were required to determine the comparability of the cost estimates of the two methods as envisaged by the second secondary objective of this study (see section 1.3.2).

In 5.2.1, the results of the inflation adjustments in question are discussed.

### 5.2.1 Results of the inflation adjustment of the 2016 HCA cost estimates of South Africa

The 2016 road traffic cost estimates were adjusted for inflation using the 2017 inflation rate of 5.3% (Stats SA, 2018b:5) to obtain the 2017 values for the purpose of this study (Labuschagne, 2016:35–43). Following are the results of the adjustment.

#### *5.2.1.1 Unit road traffic crash costs*

The 2016 road traffic unit crash costs were adjusted by a 5.3% inflation rate to obtain the 2017 road traffic unit crash costs depicted in Table 5.1 (see Annexure G for the original 2016 figures).

Table 5.1 presents the unit costs of each of the cost elements or components disaggregated by road traffic crash severity levels, namely fatal injuries, major injuries, minor injuries and damage only crashes. The cost elements are divided into three cost categories, namely human casualty cost, vehicle cost and incident cost.

**Table 5.1: 2017 road traffic unit crash costs by cost category and cost element (2017 prices in rand)**

| Cost element | Unit cost per Road Traffic Crash (RTC) (rand) | | | | |
|---|---|---|---|---|---|
| | Fatal injuries | Major injuries | Minor injuries | Damage only | Any severity |
| Human casualty | | | | | |
| Lost productivity | 3 030 720 | 228 767 | 31 068 | 2 205 | 58 264 |
| Pain, grief, suffering and lost quality of life | 2 236 566 | 302 393 | 50 027 | | 52 484 |
| Medical treatment | 154 942 | 116 521 | 34 413 | | 13 172 |
| Funeral | 17 493 | | | | 234 |
| Work place re-occupation | 72 276 | 3 105 | | | 1 117 |
| **Sub-total: Human casualty cost** | **5 511 997** | **650 787** | **115 508** | **2 205** | **125 270** |
| Vehicle repair | | | | | |
| Vehicle repair | 20 643 | 21 240 | 23 047 | 28 244 | 26 976 |
| **Sub-total: Vehicle repair cost** | **20 643** | **21 240** | **23 047** | **28 244** | **26 976** |
| Incident | | | | | |
| Emergency response | 3 203 | 2 912 | | | 183 |
| Legal | 107 009 | 107 009 | | | 6 590 |
| Vehicle-related | 3 272 | 3 366 | 3 653 | 4 476 | 4 275 |
| RTC management | 10 715 | 5 371 | 2 138 | 2 138 | 2 408 |
| Infrastructure damage | 1 681 | 1 724 | 2 130 | 2 641 | 2 502 |
| Delay congestion and emissions | 64 809 | 13 836 | 13 836 | 11 403 | 12 622 |
| **Sub-total: Incident cost** | **190 690** | **134 217** | **21 757** | **20 658** | **28 582** |
| **Total unit cost** | **5 723 330** | **806 244** | **160 313** | **51 105** | **180 829** |

It is evident from Table 5.1 that fatal road traffic crashes contributed the highest (R5 723 330) in terms of cost followed by serious injuries (R806 244). Therefore, these two severity levels constituted the highest proportion of the total unit cost.

Total road traffic crash cost estimates calculated by multiplying the unit cost in Table 5.1 with the total number of fatalities, major injuries, minor injuries and property damage only crashes are presented in the next sub-section.

#### *5.2.1.2 Total road traffic crash costs in South Africa*

Table 5.2 presents a summary of the total SA road traffic crash cost estimates per cost category and severity adjusted to 2017 by a 5.3% inflation rate (see Appendix I for the original 2016 figures).

**Table 5.2: Total road traffic crash costs by cost category and cost element**

| Cost category | Total cost of RTCs (R million) | | | | | |
|---|---|---|---|---|---|---|
| | Fatal | Major | Minor | Damage only | Total | % |
| Human casualty cost | 61 424 | 26 108 | 15 317 | 1 430 | 104 279 | 69.3 |
| Vehicle repair cost | 230 | 852 | 3 056 | 18 317 | 22 456 | 14.9 |
| Incident cost | 2 125 | 5 384 | 2 885 | 13 397 | 23 793 | 15.8 |
| **Total cost** | **63 779** | **32 344** | **21 259** | **33 145** | **150 527** | **100** |
| **Percentage** | **42.4** | **21.5** | **14.1** | **22.0** | **100** | |

According to the 2017 inflation-adjusted road traffic crash cost estimates in Table 5.2 above, the total SA national road traffic crash cost estimate for 2017 was R150 527 billion. This translates to 4.8% of South Africa's 2017 GDP of R3 124 887 trillion and R2 663.16 per capita GDP loss considering the 2017 population size of 56 521 900 for South Africa (Stats SA, 2017:2; 2018a:8). This underscores the economic impact of road traffic crashes in South Africa.

Table 5.2 further shows that of the three cost categories, human casualty costs (69.3%) contributed the most towards the overall total road traffic crash costs in South Africa followed by incident cost at 15.8%. Vehicle repair cost (14.9%) contributed the least. In terms of severity, fatal crashes made up 42.4% of the total cost followed by damage only and major crashes at 22.0% and 21.5% respectively. This shows the adverse social impact of road traffic crashes in South Africa considering the proportion human casualty costs contributed to the overall cost for the country.

#### *5.2.1.3 Road traffic crash cost distribution*

Results according to cost distribution (internal, external and insurance compensation), cost categories and cost elements calculated by adjusting the figures for 2016 reflected in Appendix J using a 5.3% inflation rate are shown in Table 5.3.

**Table 5.3: Total road traffic crash costs by cost type, category and element (rand)**

| Cost element | Internal (uncompensated victim) | External (private) (uncompensated others) | External (public sector) (uncompensated public) | Insurance (private) (compensated victim and others) | Total |
|---|---|---|---|---|---|
| **Human casualty** | | | | | |
| Lost productivity | 36 358 676 599 | 6 336 566 674 | | 5 805 465 585 | 48 500 708 857 |
| Pain, suffering and lost quality of life | 36 982 974 472 | 4 622 871 810 | | 2 082 844 013 | 43 688 690 295 |
| Medical treatment | | | 9 850 093 862 | 1 114 517 226 | 10 964 611 088 |
| Funeral | 165 667 852 | | | 29 269 836 | 194 937 686 |
| Work place re-occupation | | 929 994 393 | | | 929 994 393 |
| Sub-total: Human casualty cost | 73 507 318 922 | 11 889 432 876 | 9 850 093 862 | 9 032 096 659 | 104 278 942 320 |
| **Vehicle repair** | | | | | |
| Vehicle repair | 12 988 281 686 | | | 9 467 551 060 | 22 455 832 746 |
| Sub-total: Vehicle repair cost | 12 988 281 686 | | | 9 467 551 060 | 22 455 832 746 |
| **Incident** | | | | | |
| Emergency response | | | 25 696 629 | 126 817 835 | 152 514 463 |
| Legal | | | | 5 485 365 626 | 5 485 365 626 |
| Vehicle-related | | | | 3 558 840 963 | 3 558 840 963 |
| RTC management | | | 2 004 863 082 | | 2 004 863 082 |
| Infrastructure damage | | | 2 082 979 883 | | 2 082 979 883 |
| Delay congestion and emissions | | 10 507 626 851 | | | 10 507 626 851 |
| **Sub-total: Incident cost** | | **10 507 626 851** | **4 113 539 593** | **9 171 024 425** | **23 792 190 869** |
| **Total cost** | 86 495 600 608 | 22 397 059 726 | 13 963 633 455 | 27 670 672 145 | **150 526 965 936** |

The second column (internal [uncompensated victim]) indicates the costs incurred by the road traffic crash victims themselves, which constituted 57% of the total road traffic crash cost in South Africa (Labuschagne, 2016:36).

The third and fourth columns show costs that were borne by third parties as a result of road users involved in road traffic crashes. According to Labuschagne (2016:36):

> ‘External (private) (uncompensated others)’ refers to private third parties that may include a victim’s household, family and friends in the case of the ‘pain, grief and suffering and lost quality of life’ cost element. It may also include other road users as in the case of the ‘delay, congestion and emissions’ cost element. ‘External (public sector) (uncompensated others)’ relates largely to the public sector or government. For example, the ‘medical treatment’ cost element refers to cost borne by public hospitals. Road traffic crash management and infrastructure damage costs are also borne by the public sector. External costs constitute 24% of the total road traffic crash cost.”

The second last column (insurance [private – compensated victim and others]) shows costs compensated by entities such as the RAF and vehicle insurance companies. This contributed 18% towards the total road traffic crash costs.

Noteworthy is that Labuschagne (2016:37) acknowledges that due to a lack of data on road traffic crash costs, involving government vehicles for example, no vehicle repair costs for the public sector could be calculated. Furthermore, in terms of the 2016 costs regarding ‘workplace re-occupation’ cost element, an amount of R883 million has been attributed to the private sector. However, not enough information was available to distribute this figure properly between the private and public sectors. Therefore, this figure may also underestimate the impact that employee absences as a result of road traffic crashes and road traffic injuries have on employers. It is therefore critical that effort be put into improving the quality and completeness of data in this regard.

The third secondary objective of this study aimed at determining the comparability of the SA road traffic crash cost estimates of the HCA and those of the WtPA. In order for this comparison to be possible, there is therefore a need to calculate cost estimates using the WtPA as well. The next section therefore presents the results of this approach.

### 5.2.2 Results of the WtPA

A WtP questionnaire was developed and administered to 209 employees of the DoT, RAF, RTIA, RSR, RTMC, C-BRTA and SANRAL. Of these, 208 responses were found to be valid for purposes of this study. The results of the questionnaire are provided next. It needs to be emphasised that, for the purpose of this study, the sample was not representative of the SA population (see 4.5.2.2.1 for the rationale behind the sample used in this study). The respondents were sampled to illustrate the application of the hybrid framework proposed in this study for the assessment of the cost of road traffic crashes.

The first part of the WtP questionnaire required respondents to provide information regarding their personal characteristics such as –

- their demographic characteristics, economic status and travel behaviour;
- characteristics as well as road crash history of self and family or close relative and anxiety; and
- worries that they themselves or their family or close relatives could be involved in road traffic crashes.

Information about demographic characteristics they were required to provide related to their education, age and gender. Information on economic status and travel behaviour and characteristics respondents were asked to provide entailed their monthly income, car or vehicle ownership, time they spend travelling per day, their mode of travel and their reasons for travelling. Lastly, respondents were also asked to provide information on their road crash and anxiety profile in terms of whether they or a family member or a close relative had been involved in road crashes in the past, and whether they were anxious or worried that they or their family member or close relative might be involved in a road traffic crash. In case the respondent or their family member or close relative had been involved in a road traffic crash, respondents were also asked to indicate the severity of their injury.

Figure 5.2 shows the frequency distribution of respondents across positions identified in the questionnaire.

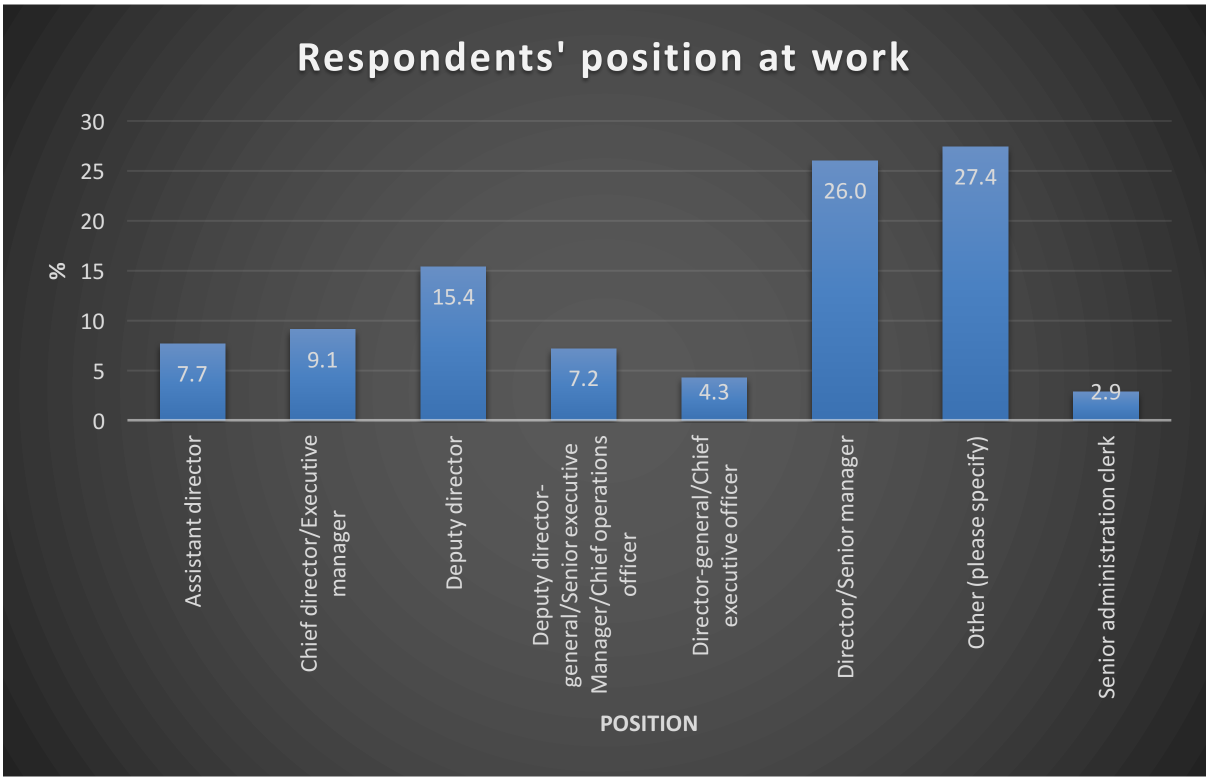


**Figure 5.2: Respondents' positions at work**

It is evident from Figure 5.2 that the 'Other' category of positions at work constituted the most respondents (27.4%) followed closely by positions of director/senior manager (26%). Senior admin clerks were the category with the least respondents (2.9%). Under the 'Other' category, the following positions were amongst those specified by respondents. These were across all levels in national organisations located in Gauteng, South Africa:

- accident assessor;
- acting deputy director-general;
- chairperson: National Interfaith Road Safety Ambassadors;
- chief forensic investigator;
- detective sergeant;
- communication officer;
- insurance risk manager;
- fieldworker;
- inspector Metro Police;
- lecturer (at the RTMC Training Academy);
- junior lecturer (at the RTMC Training Academy);
- monitoring and evaluation specialist;
- mechanical crash investigator;

- operations manager;
- political strategic advisor;
- provincial coordinator; and
- representation officer.

It is important to specify these positions because most of them are equivalent to those specified in the questionnaire. For example, the positions of:

- acting deputy director-general is equivalent to the position of deputy director-general or senior executive manager or chief operations officer;
- political strategic advisor, operations manager, insurance risk manager and chief forensic investigator are equivalent to the position of senior manager; and
- provincial coordinator, inspector Metro Police, lecturer (at the RTMC Training Academy), monitoring and evaluation specialist, mechanical crash investigator and representative officer are equivalent to the position of deputy director.

This demonstrates that even if designations other than those specified in the questionnaire were used for these respondents, the respondents still fell within the categories of either supervisory or management positions.

In order to identify respondents who understood the risk of motor vehicle crashes, the WtP questionnaire also had a question prompting respondents to choose between two routes of different risk levels. This question was intended to verify whether respondents understood risk. Respondents who answered this question incorrectly showed that they did not understand the risk proportion thus leading to a conclusion that their subsequent answers were unreliable (Abdallah et al., 2016:13; Le et al., 2011:4). It is for this reason that only WtP responses of respondents who chose a less risky route were used to calculate the VoSL for use when calculating the cost of crashes. As recommended by Abdallah et al. (2016:13) and Le et al. (2011:4), responses of participants who answered the question incorrectly were excluded from further analysis since they were viewed as unreliable.

Figure 5.3 depicts the results of participants' responses to the question to determine understanding of risk.

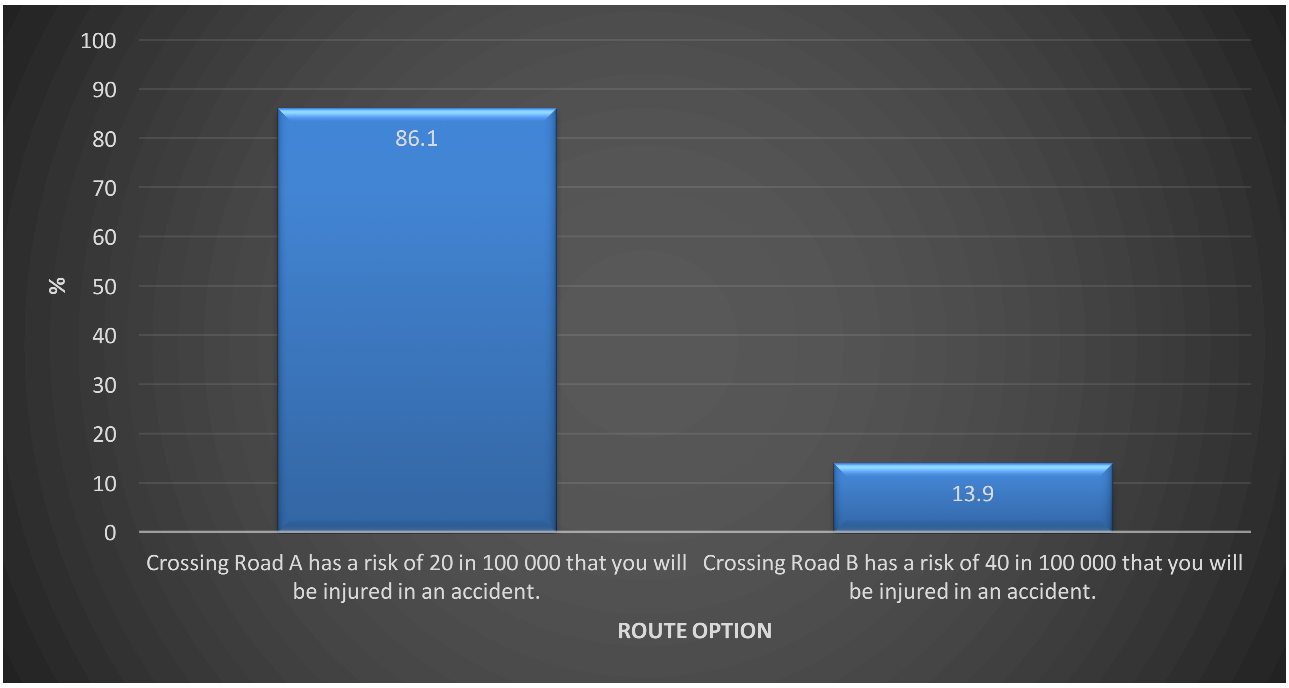


**Figure 5.3: Participants' understanding of motor vehicle crash risk in relation to route choices**

Just over 86% (179) of the respondents chose Route A, which was the less risky choice, thus showing an understanding of the risk of being involved in a motor vehicle crash depicted in the two route option scenarios in Figure 5.3. These respondents were therefore the ones whose responses were considered for the calculation of the VoSL for use in estimating the cost of road accidents using the WtPA. In line with Abdallah et al. (2016:13) and Le et al. (2011:4), the 29 (13.9%) respondents who chose Route B, which was a risky route, were left out for this purpose since their choice was an indication that they did not understand the risk proposition and therefore their subsequent answers were deemed unreliable. The following sub-sections provide the main characteristics of the respondents.

#### *5.2.2.1 Demographic profile of the respondents*

Figure 5.4 summarises the demographic characteristics.

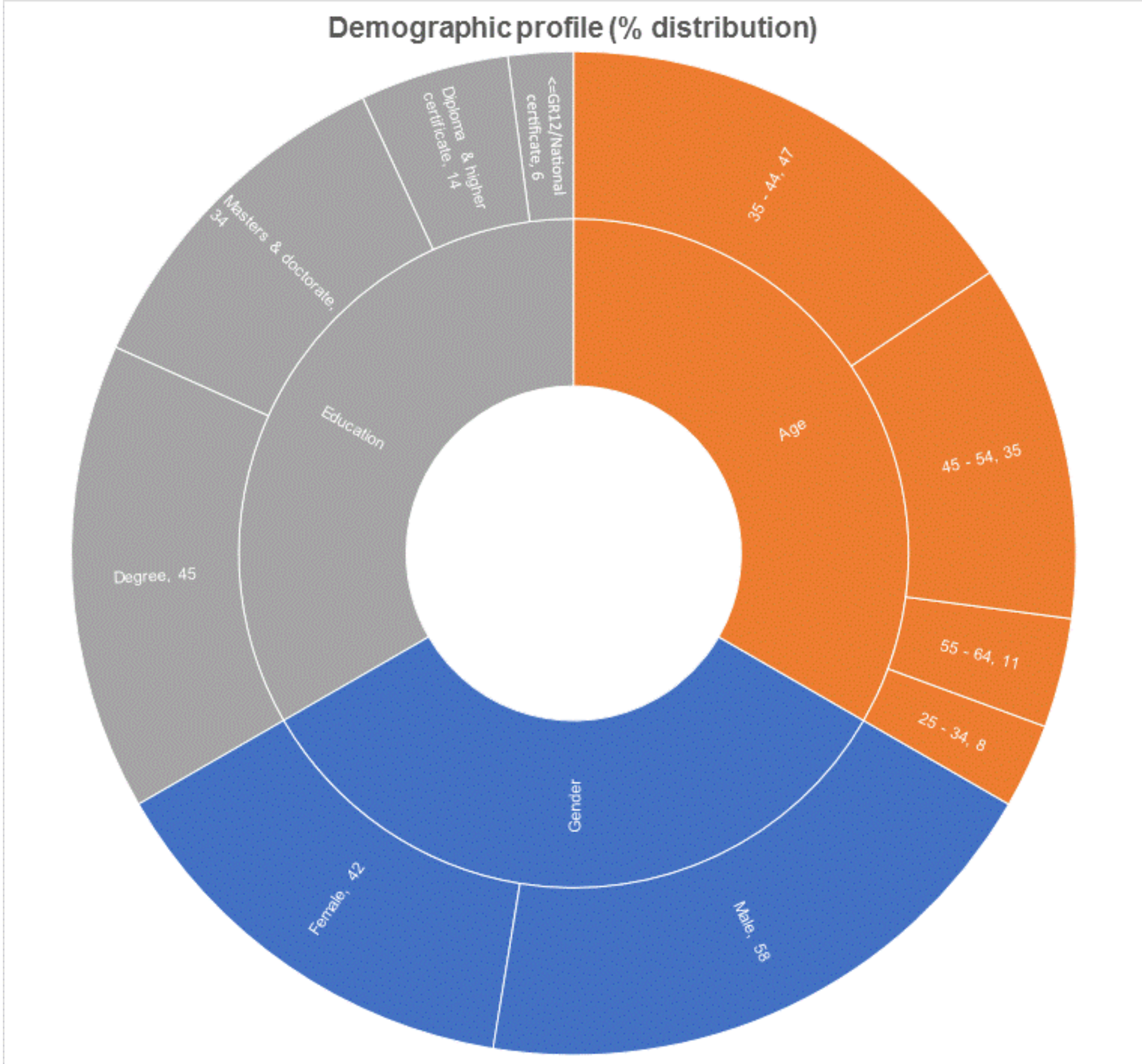


**Figure 5.4: Characteristics of the respondents**

Figure 5.4 shows that:

- The majority (81.2%) of the respondents were aged between 35 and 54. The youngest group (between 25 and 34) was the least represented group at only 8.2% of the total number of respondents. None of the respondents fell within the 18–24 age category and as a result, this category was left out of Figure 5.3. Furthermore, this study only targeted employed people, thus excluded people aged 65 and over as well as the age category 18–24 as they were still busy with obtaining formal educational qualifications. The fact that the majority of the respondents were aged between 35 and 54 is a positive observation since this age group was still active in the economy; thus, they were most vulnerable to the risk of injury in road traffic crashes since their work demands intensive travelling as well in some cases.

- Of the respondents, 88 (42.3%) were female and 120 (57.7%) were male, indicating that males were the majority of the respondents. This augurs well for this study since males constitute the majority of road traffic crash victims in South Africa (see RTMC, 2013; 2014; 2015; 2016; 2017).
- The majority (79.3%) of respondents had a bachelor's or first degree (45.2%) followed by those who had postgraduate degrees at 34.1%. Only 6.3% of the respondents had Grade 12 (completed secondary schooling) or less as highest qualification. Therefore, in addition to their level of understanding of transport issues as a result of their positions at work, respondents' level of education also gave them an advantage since the survey questions were in English.

### *5.2.2.2 Economic status and travel behavioural characteristics of respondents*

The economic status and travel behaviour characteristics of the respondents are summarised in Figure 5.5.

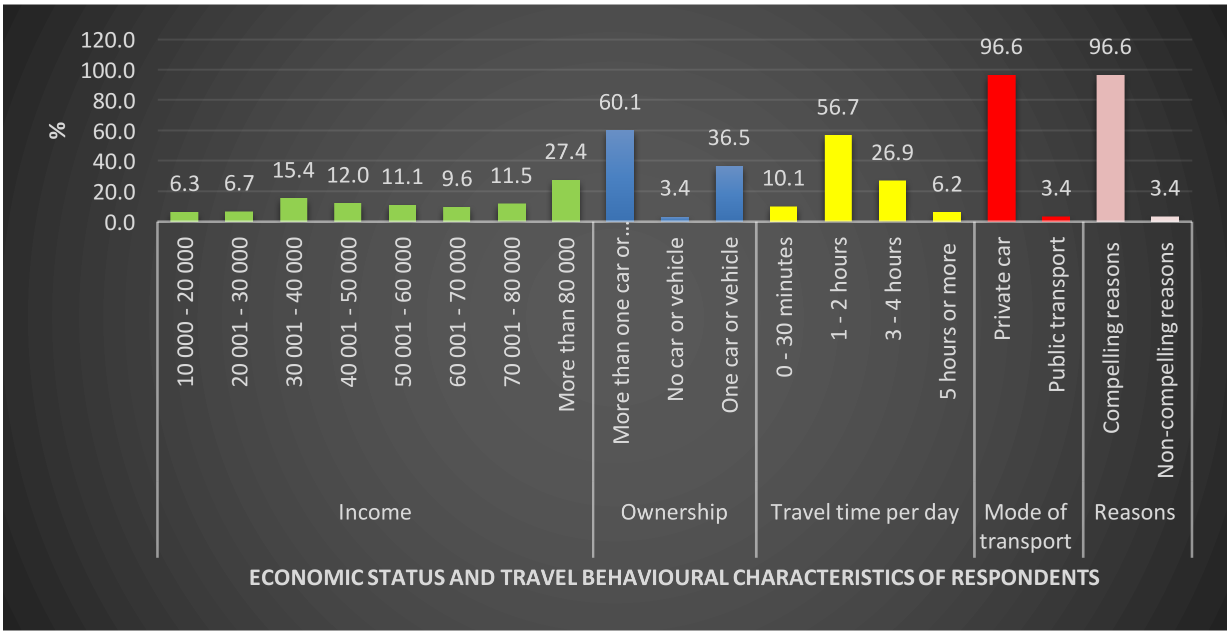


**Figure 5.5: Economic status and travel behavioural characteristics of respondents**

It is evident from Figure 5.5 that:

- Over 27% of the respondents earned a gross income of more than R80 000 per month, which was in line with the job levels indicated, while the rest of the respondents were distributed fairly evenly over most of the other categories, except for the lowest two categories. Only 13 respondents (6.3%) were in the lowest gross income category of R10 000–20 000 per month. The fact that the respondents earned at least R10 000 per month showed that they could afford to pay an amount to alleviate their risk of injury in road traffic crashes.

- Almost two-thirds (60.1%) of respondents indicated that they had more than one car or vehicle. Only seven (3.4%) respondents indicated that they did not have a car and thus made use of public transport. The remainder (37%) of the respondents reported that they had one car only. The fact that the majority of the respondents indicated that they had more than one car or vehicle meant that, ideally, their family members had access to a car to travel on their own. This increased the exposure of both the respondents and their family members to the risk of getting involved in motor vehicle crashes.
- The majority (83.6%) of the respondents indicated that they travelled between one and four hours per day, which made them vulnerable to the risk of getting involved in road traffic crashes.
- Almost all (201 or 96.6%) of the respondents used private vehicles for their daily travel and the remaining seven (3.4%) used public transport. This increases traffic volumes on the road network and increases the chances of involvement in motor vehicle crashes. Furthermore, with the majority of the respondents using private vehicles for their daily travel, it goes without saying that most of the respondents faced a relatively high risk of getting involved in motor vehicle crashes.
- Almost all the respondents (96.6%) indicated that they travelled for such compelling reasons as work, study and hospital or clinic consultations, amongst others. These reasons were therefore of a serious nature, and they were bound to travel, which increased their travel frequency. These reasons did not give them options to decide on the time of travel and this could force them to travel even during peak hours therefore increasing their risk of getting involved in road traffic crashes.

The road traffic crash and anxiety profile of respondents are presented and discussed in the next section.

#### *5.2.2.3 Road traffic crash and anxiety profile of respondents*

This section provides the results on whether respondents or their family members:

a. were anxious or worried about the risk of them or their close family members getting involved in motor vehicle crashes; and
b. had been involved in motor vehicle crashes in the past. In cases where respondents reported that they or their family members or close relatives had been involved in a motor vehicle crash in the past, they were prompted to indicate the severity of injury

of those who had been involved in motor vehicle crashes. The severity levels they had to choose from were ‘fatal injury’, ‘major or serious injury’ and ‘minor injury’.

A summary of the responses provided by respondents is presented in Figure 5.6.

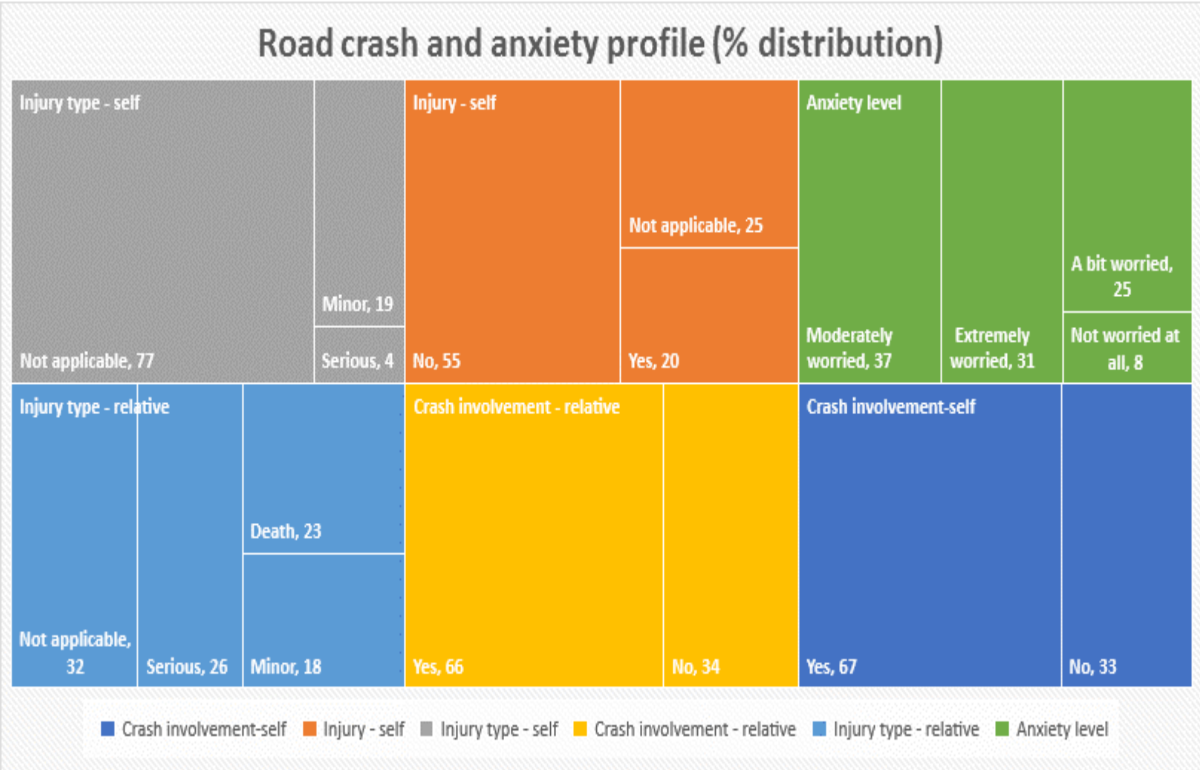


**Figure 5.6: Road traffic crash and anxiety profile of respondents**

From Figure 5.6 it is evident that:

- Approximately two thirds (66.8% or 139) of the respondents reported that they have been involved in a motor vehicle crash in the past. Of these 139 respondents, 42 (or 30.2%) (or 20.2% of the total number of respondents = 208) indicated that they had sustained injuries. Therefore, the respondents would ideally be willing to pay to reduce their risk of injury on the road, given their experience.
- The majority (just over 92%) of the respondents expressed a level of anxiety about the risk of them or their close family members being involved in a road crash. Therefore, it would make sense for these respondents to want to pay more to reduce the risk of them or their family members or close relatives getting involved a motor vehicle crash. Of these respondents, 76 (36.5%), 64 (30.8%) and 52 (25.0%) indicated that they are moderately worried, extremely worried and a bit worried respectively. The remaining 16 (7.7%) indicated that they were not worried at all. This could possibly be due to minimal travel on the side of these respondents and

their close family members or owning relatively safe cars resulting in a perceived false sense of safety. However, almost half (46.6%) of the overall number of valid responses (208) indicated that they did not sustain any injury.

- Just over two thirds (67.8% (141)) of the respondents indicated that their family member or close relative had been involved in a motor vehicle crash in the past. Furthermore, these respondents reported that their family member or close relative had sustained injuries in a motor vehicle crash in the past. Of these, 26.4% had sustained serious injuries, 23.1% sustained fatal injuries and 18.3% sustained minor injuries for this selected group. Therefore, it is expected that this experience would make the respondents more willing to pay for a reduced risk of injury in road traffic crashes.

The third secondary objective of this study was to determine the comparability of the HCA crash cost estimates to those calculated using the WtPA (see section 1.3.2). Furthermore, the second secondary objective aimed to investigate empirically the WtPA in the SA context (see section 1.3.2). Therefore, in order for the comparison envisaged by the third secondary objective to be possible, there was a need to calculate WtP road crash cost estimates as part of the empirical investigation of the WtPA envisaged by the second secondary objective. However, two WtPA methods were identified through review of literature as reflected in Chapter 2 and applied in this study, namely the CVM and the SPM. Therefore, there was a need to determine crash cost estimates using both methods. For this reason, the next sub-section presents the results of the analysis of the CV data. Those of the SPM will be presented in 5.2.2.6.

#### *5.2.2.4 CVM*

As part of investigating the applicability of the WtPA, it was necessary to calculate the cost of road traffic crashes using each of the two methods identified for use in this study, namely the CVM and the SPM. This section presents and discusses the results of the CVM.

In order to collect CV data, all the respondents were required to answer road crash CV questions in the first questionnaire. Even though a total of 209 respondents answered the full questionnaire, only 208 respondents were found to have provided valid responses to this section and the rest of the questionnaire. However, only the responses of the 179 respondents who were found to have understood risk were used for the CV analysis reflected in this report. The questions comprised two parts as shown in Table 4.4 and Appendix C, namely the risk question (question 2.1) and the WtP question (question 2.2).

The frequency figures for the number of respondents choosing each one of the cost options in the WtP questions are presented in the second and third columns of Table 5.4 for 30% and 50% risk reduction respectively.

**Table 5.4: Daily contingent valuation (CV) value (WtP for road crash risk reduction)**

| WtP amount (in rand) per day | Option A (30% risk reduction) | Option B (50% risk reduction) |
|---:|---:|---:|
| 7.40 | 96 | 77 |
| 14.79 | 12 | 22 |
| 22.19 | 16 | 12 |
| 29.59 | 7 | 14 |
| 36.99 | 7 | 5 |
| 44.38 | 6 | 9 |
| 51.78 | 7 | 7 |
| 59.18 | 3 | 5 |
| 66.58 | 6 | 6 |
| More than 66.58 | 19 | 22 |
| **Total** | **179** | **179** |

In order to determine total cost per year for each of the daily cost figures above, each of the figures was multiplied by 250, which was the total number of days considered working weekdays per annum for the purpose of this study. The annual CV values, which also represented respondents' willingness to pay to reduce the risk of road traffic crash injury, were obtained by multiplying the cost figures in Table 5.4 by 250 to obtain annual WtP figures that are presented in Table 5.5. These figures represent amounts respondents were willing to pay per annum for each one of the two risk reduction probabilities, namely 30% and 50% risk reduction.

**Table 5.5: Annual contingent valuation of respondents' willingness to pay in relation to percentage change in risk level considering all respondents**

| WtP amount (in rand) per year | Option A (30% risk reduction) | Option B (50% risk reduction) |
|---:|---:|---:|
| 1 850 | 96 | 77 |
| 3 697.5 | 12 | 22 |
| 5 547.5 | 16 | 12 |
| 7 397.5 | 7 | 14 |
| 9 247.5 | 7 | 5 |
| 11 095 | 6 | 9 |
| 12 945 | 7 | 7 |
| 14 795 | 3 | 5 |
| 16 645 | 6 | 6 |
| More than 16 645 | 19 | 22 |
| **Total** | **179** | **179** |

As Tables 5.4 and 5.5 as well as Figures 5.7 and 5.6 show:

- Overall, the most respondents, 96 or 53.6% for 30% risk reduction and 77 or 43% for 50% risk reduction, were willing to pay the lowest amount, which was R1 850 per annum, irrespective of change in the percentage risk of injury in road traffic crashes. It is also interesting that fewer respondents were willing to pay the lowest amount (i.e. R1 850) for a 50% reduction in the risk of road injury than those that were willing to pay the same amount for a 30% risk reduction. This shows that respondents could probably not differentiate risk reductions in proportion to favourable change in risk probabilities.

The information in Table 5.5 is graphically presented in Figure 5.7.

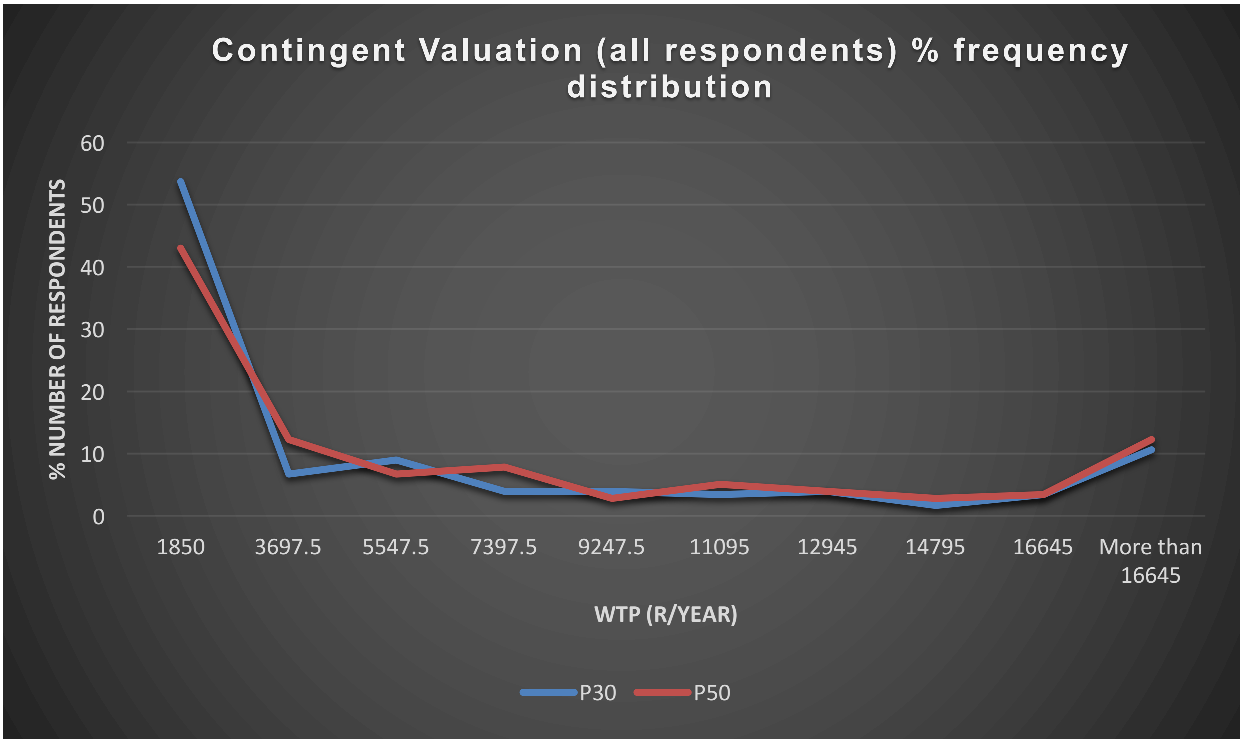


**Figure 5.7: Annual contingent valuation of respondents' willingness to pay in relation to percentage change in risk level considering all respondents (% frequency distribution)**

Tables 5.5 and Figure 5.7 also show that, despite the drastic decrease in the number of respondents as amounts respondents are willing to pay increase, more respondents were willing to pay more for a 50% reduction in the risk of road injury. Although maintaining the same trend, there was also an observed increase in the number of respondents willing to pay the highest amount, namely more than R16 646 per annum for both the 30% and 50% reduction in the risk of road injury. However, there were more respondents willing to pay this amount for a 50% reduction in the risk of road traffic injury. This shows that, despite some slight misunderstanding of risk, respondents realised that the higher risk reduction probability, namely 50%, meant improved safety on their part.

The same trend shown in Table 5.5 and Figure 5.7 was maintained even if respondents who did not own vehicles were excluded. This is shown in Table 5.6 and also depicted in Figure 5.8, which presents the frequency distribution of respondents' willingness to pay in percentage form. Therefore, the inclusion of respondents who did not own a car did not have any significant influence on the WtP levels already observed when all the respondents were considered.

**Table 5.6: Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level considering only respondents who owned cars or other vehicles**

| WtP amounts (rand) | Option A (30% risk reduction) | Option B (50% risk reduction) |
|---:|---:|---:|
| 1 850 | 93 | 74 |
| 3 697.5 | 12 | 22 |
| 5 547.5 | 15 | 12 |
| 7 397.5 | 7 | 13 |
| 9 247.5 | 7 | 5 |
| 11 095 | 6 | 9 |
| 12 945 | 7 | 7 |
| 14 795 | 3 | 5 |
| 16 645 | 6 | 5 |
| More than 16 645 | 17 | 21 |
| **Total** | **173** | **173** |

The highlighted figures in Table 5.6 are those that changed from Table 5.5 as a result of excluding respondents who did not own a car. The information in Table 5.6 is further depicted in Figure 5.8 below presenting the percentage of respondents choosing each one of the WtP amounts under each one of the two risk reduction probabilities, namely 30% and 50%.

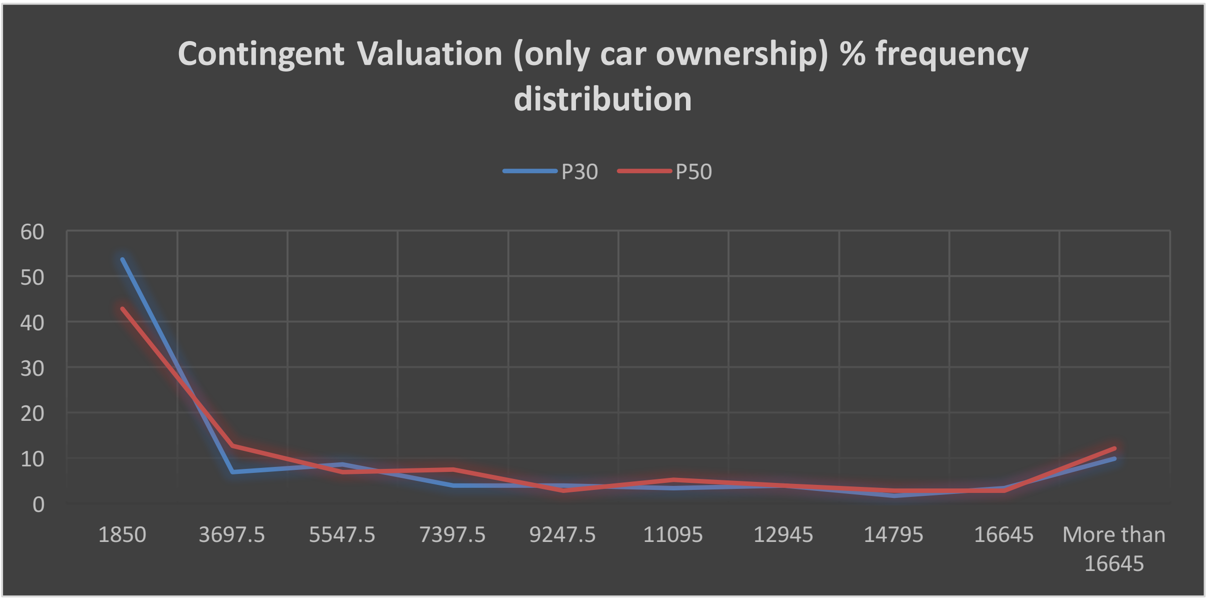


**Figure 5.8: Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level considering only respondents who owned cars or other vehicles (% frequency distribution)**

The mean and median values of annual willingness to pay for road crash risk reduction were calculated for Option A and Option B based on the responses reflected in Table 5.6 after excluding the 29 (13.9%) respondents who failed the understanding of risk question. Table 5.7 shows the resulting values of risk reduction.

**Table 5.7: Value of accident risk reduction (rand per year)**

| Option | Mean | N | Std. deviation (SD) | Median |
|---|---|---|---|---|
| A (30% risk reduction) | 6 724.50 | 179 | 7 487.12 | 1 850.00 |
| B (50% risk reduction) | 7 566.94 | 179 | 7 740.78 | 3 697.50 |
| Average of both options | 7 145.72 | 179 | 7 613.95 | 2 773.75 |

Table 5.7 shows that the mean and median values of road crash risk reduction were R6 724.50 and R1 850.00 per annum for Option A (30% risk reduction), and R7 566.94 and R3 697.50 for Option B (50% risk reduction) respectively. The last category (more than R16 645) was coded with a middle value of R25 000. As this category had a fairly high number of respondents (11.1% and 13.5% respectively for the 30% and 50% risk reduction), the researcher is aware of the influence of this category on the overall mean. The very high SD values for both Option A and Option B mean that annual WtP values of individual respondents were spread out over a large range of values from the mean values.

Further insight was obtained by determining the average WtP amount per year for each category of the following variables: income, gender, age, vehicle ownership, previous involvement in motor vehicle crash, either self or close family member or relative having sustained injuries in a motor vehicle crash as well as education. Results for these variables are discussed in sub-sections (a) to (g) below.

*(a) Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level by income level*

Figure 5.9 depicts respondents' willingness to pay to reduce their risk of road crash injury relative to their income levels.

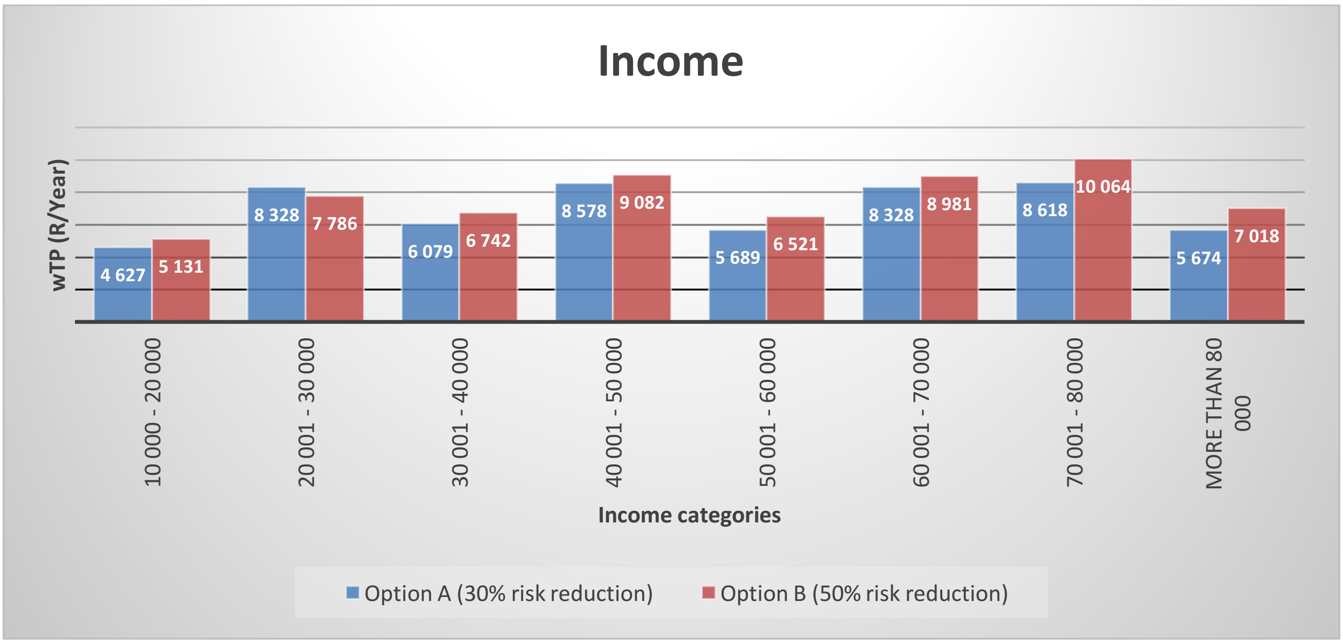


**Figure 5.9: Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level and their income level**

With the exception of those within the income category 20 001–30 000, Figure 5.9 shows that all the other respondents were willing to pay more for a 50% reduction in their risk of getting injured in a road crash. What remains difficult to explain, though, is the observation that overall, the respondents within the highest income category ('More than R80 000') were willing to pay relatively low amounts to reduce their risk of road injury irrespective of a sizeable increase in percentage reduction in the risk of injury. This is contrary to findings of previous studies that WtP increases with mean income (Jacobsen & Hanley, 2009:n.p.; Raumgärtner, Drupp, Meya, Munz & Quaas, 2016:1). This could arguably be attributed to their ability to afford cars with all safety features as a result of their high-income levels. This therefore results in a false sense of security. Furthermore, it could also be a function of respondents not necessarily believing that them paying more money to reduce their risk of road crash injury will not reduce their risk of injury since the money is not spent on improving road safety necessarily.

*(b)* *Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level by gender*

Figure 5.10 illustrates the contingent valuation of respondents' willingness to pay in relation percentage change in risk level by gender.

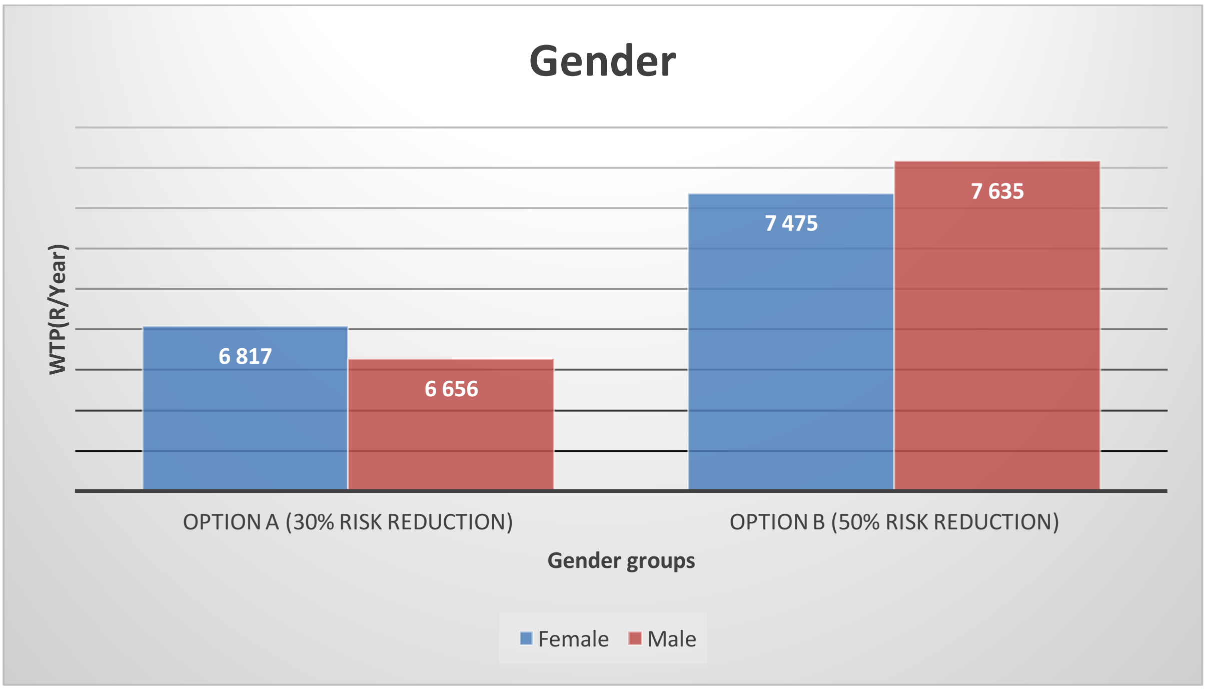


**Figure 5.10: Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level by gender**

Figure 5.10 shows that male respondents were willing to pay less (R6 656) per annum compared to their female counterparts (R6 817) at a 30% risk reduction rate. However, male respondents' WtP increases marginally to R7 635, i.e. a 14.7% or R979 increase, when the risk reduction rate increases to 50% compared to that of their female counterparts, which increases from R6 817 to R7 475, which is a 9.7% or R658 increase. This could be attributed to the fact that more males die in road crashes than their female counterparts in South Africa (RTMC, 2015:45; 2016:25, 36; 2017:25). For example, for the years 2015, 2016 and 2017, South Africa recorded percentage ratios of 74% male to 20.8% females (9 575 males to 2 696 females), 77% male to 23% female (10 835 males to 3 236 females) , 76.8% male to 22.7% female (i.e. 10 802 males to 3 198 females) respectively (RTMC, 2015:45; 2016:25, 36; 2017:25).

*(c) Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level reduction by age*

Contingent valuation of respondents' willingness to pay in relation to the percentage change in risk level by age is depicted in Figure 5.11.

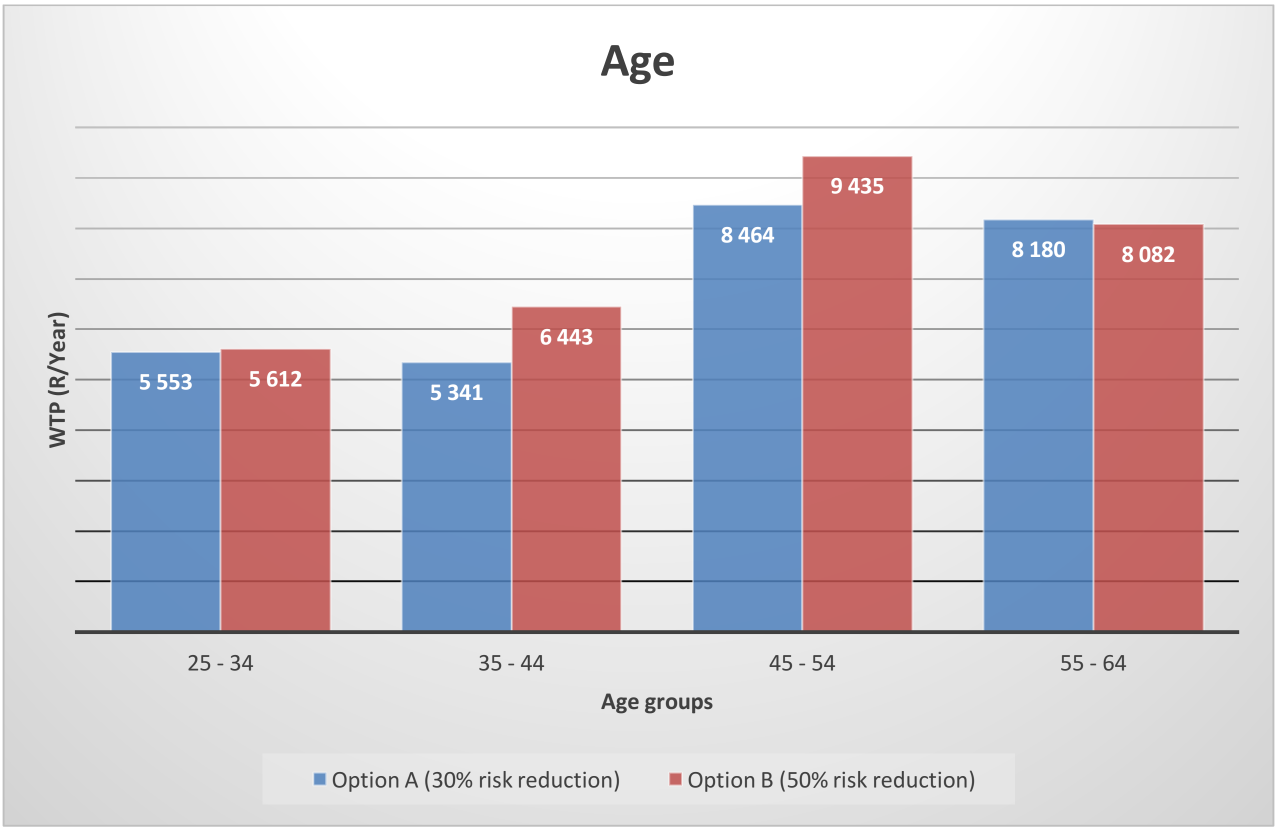


**Figure 5.11: Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level by age**

It is evident from Figure 5.11 that respondents' willingness to pay consistently increased with age until the age category 45–54 for a 50% risk reduction probability, that is 14.8% or R831 and 46.4% or R2 992 for the age categories 25–34 to 35–44 and 35–44 to 45–54 respectively. On the other hand, for a 30% risk reduction probability, there was firstly a slight decrease of 3.8% or R212 in respondents' willingness to pay for the age categories 25–34 to 35–44 followed by a significant increase of 58.5% or R3 123 for the age categories 35–44 to 45–54. The observed increases in the amounts respondents were willing to pay from one age category to the next could be a function of increases in income due to respondents' career progression during these prime years of economically active citizens. In support of this assertion, previous studies also found income to be positively related to willingness to pay and that willingness to pay increases with mean income (Jacobsen & Hanley, 2009:n.p.; Raumgärtner et al., 2016:1).

Interestingly, if we consider amounts respondents within the age category 45–54 were willing to pay as base values for the 30% and 50% risk reduction probabilities, respondents' willingness to pay reduced at age category 55–64 by 3.4% or R284 and 14.3% or R1 353 respectively. This could be attributed to road users' reduction in travel, confidence in their driving skills resulting in a perceived reduced risk of getting involved in a road crash, and being more cost-conscious as they near retirement. Again, the relatively low amounts for younger respondents could be attributed to their high risk-taking tendencies, peer pressure as well as generally low income levels. It is however encouraging that the leading contributor for the age category 25 to 54 towards fatalities in South Africa showed increases in their willingness to pay in proportion to an increase in risk reduction probabilities. This is the case because this is the age category adversely affected by road traffic crashes in South Africa in terms of road traffic fatalities (RTMC, 2015:47; 2016:42; 2017:26).

*(d) Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level by vehicle ownership status*

Figure 5.12 depicts the extent to which respondents' willingness to pay was sensitive to change in risk probability level aggregated by their vehicle ownership profiles.

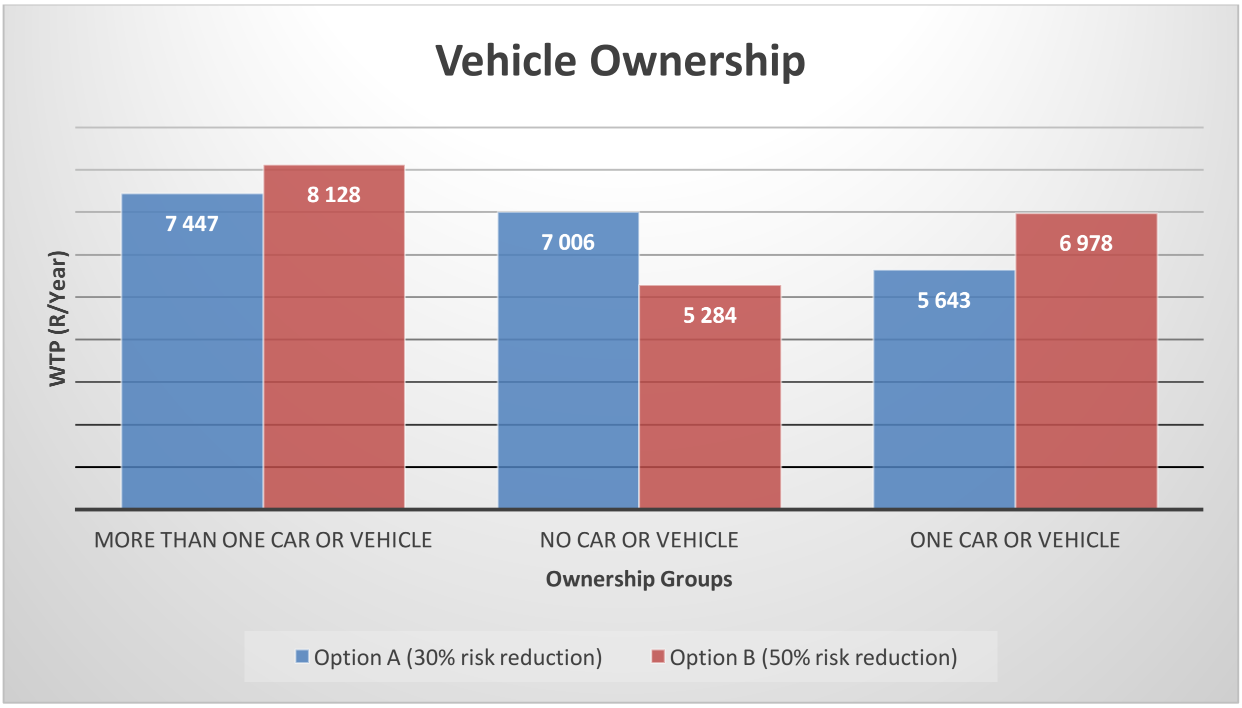


**Figure 5.12: Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level by vehicle ownership profile**

It is clear from Figure 5.12 that respondents who reported that they did not own a car or vehicle were not willing to pay more to reduce their risk of injury in road crashes as the percentage reduction increases. This could be due to either affordability or to a perception that they were less likely to be injured in car crashes since they did not own a motor vehicle themselves, or they generally had lower income levels. Therefore, vehicle ownership influenced respondents' willingness to pay to reduce the risk of road traffic injury.

Noteworthy is also the observation that respondents with more than one vehicle expressed the highest willingness to pay to reduce their risk of road injury compared to their counterparts in the other two categories. Furthermore, the former cohort registered a 9.1% or R681 increase in their willingness to pay compared to the latter, which recorded a relatively higher increase of 23.7% or R1 335. This could be attributed to their perceived cumulative risk of road injury not only for themselves, but also for their family members. The same reasoning could apply to the respondents who owned one car. Therefore, the number of vehicles or cars respondents owned played a role in determining their WtP levels.

*(e) Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level by history of involvement in road crashes*

Figure 5.13 indicates the sensitivity of respondents' willingness to pay in relation to change in risk probability level by their history of involvement in road crashes.

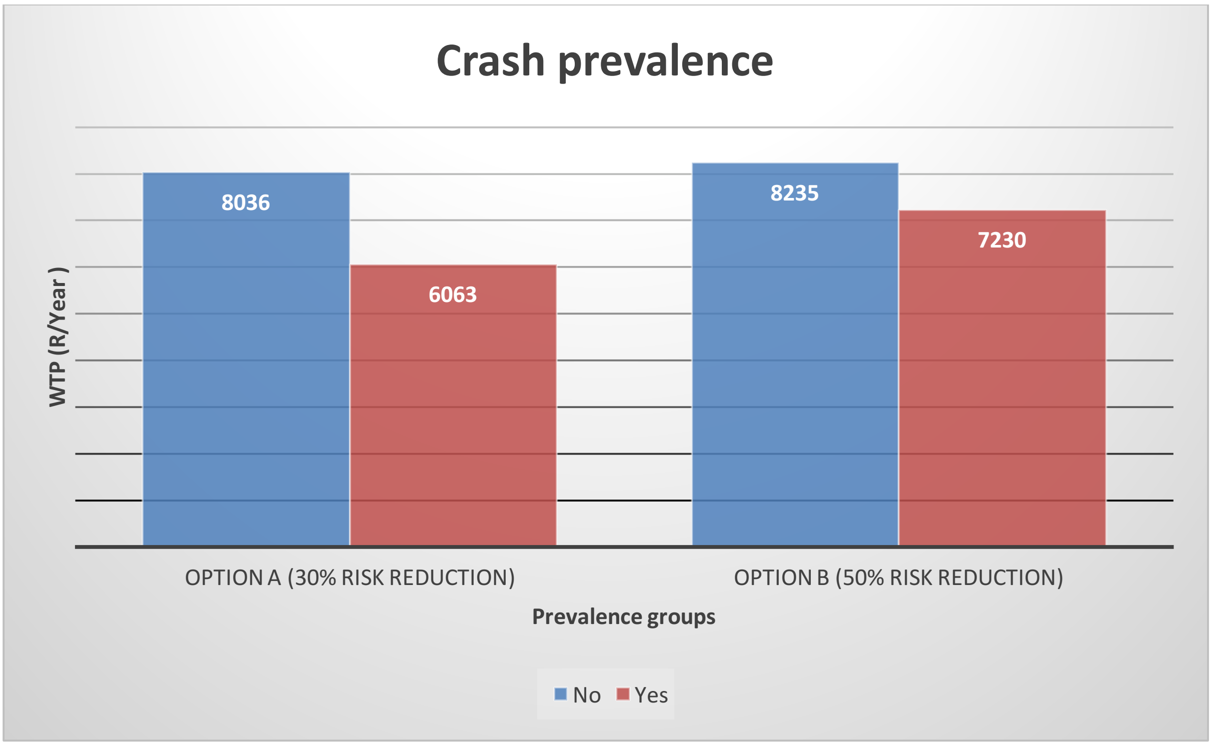


**Figure 5.13: Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level by history of road crash involvement**

It is intriguing to note that respondents who reported not to have been involved in any road crash in the past were willing to pay more than those who had been involved in road crashes previously. This could be due to the preventative behaviour of those who reported not to have been involved in any road crash in the past by avoiding risky driver behaviour on the road and also investing in safer vehicles than their counterparts. As is evident from Figure

5.13, both cohorts however showed a willingness to pay more to reduce their risk of injury as the risk reduction probability increased from 30% to 50%. It is against this background that respondents who indicated that they had never been involved in any road crash in the past showed a 2.5% or R199 increase in their willingness to pay for an increase in risk reduction probability from 30% to 50%. Furthermore, those who indicated that they had been involved in a motor vehicle crash in the past recorded a 19.2% or R1 167 increase in their willingness to pay for an increase in risk reduction probability from 30% to 50%. Therefore, even though they were willing to pay less than those who had never been involved in a motor vehicle crash in the past for both risk reduction probabilities, the respondents who were involved in a road crash before were willing to pay far more than those who had never been involved in road crashes.

*(f) Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level by history of injury in road crashes*

Figure 5.14 depicts the contingent valuation of respondents' willingness to pay in response to change in the risk level of road injury by their history of injury in road crashes.

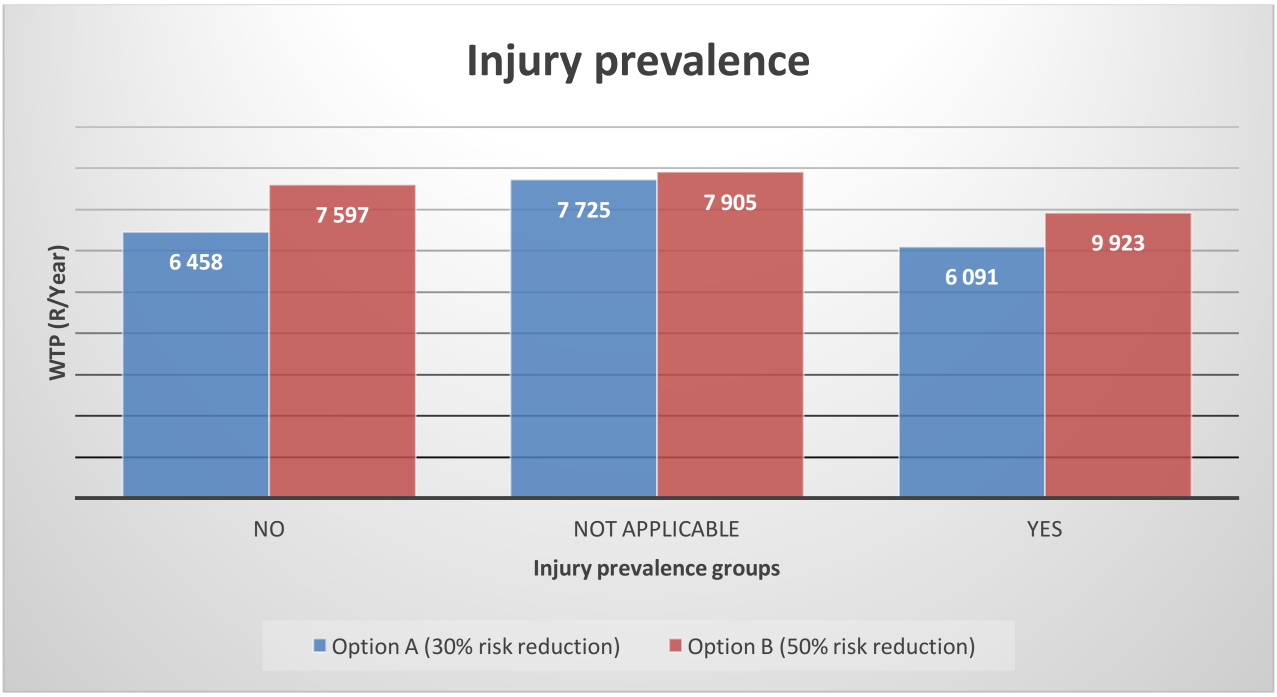


**Figure 5.14: Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level by history of injury in road crashes**

It is worth noting that respondents who reported that they have sustained injuries in road crashes in the past were willing to pay less than those who had never sustained injuries in road crashes. This is evident from Figure 5.14, which shows that respondents who had sustained injuries in a road crash in the past were willing to pay 5.7% or R367 and 8.9% or R674 less than those who had never sustained injuries in a road crash before for a 30% and 50% risk reduction respectively. Furthermore, those who had been never involved in road crashes and therefore never sustained injuries were willing to pay the most average amounts per annum for both 30% and 50% risk reduction probabilities. The reason why these people have never been involved in road crashes could possibly be because they had invested in safe vehicles and avoided risky road user behaviour as well. Furthermore, they might have been willing to pay most to reduce the risk of motor vehicle injury as a preventative measure. Therefore, having sustained injuries in a road traffic crash had a negative effect on respondents' willingness to pay for reduction in the risk of road traffic crash injury.

*(g) Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level by their education level*

In Figure 5.15, the extent to which respondents' willingness to pay was sensitive to percentage change in risk level by their education level, is illustrated.

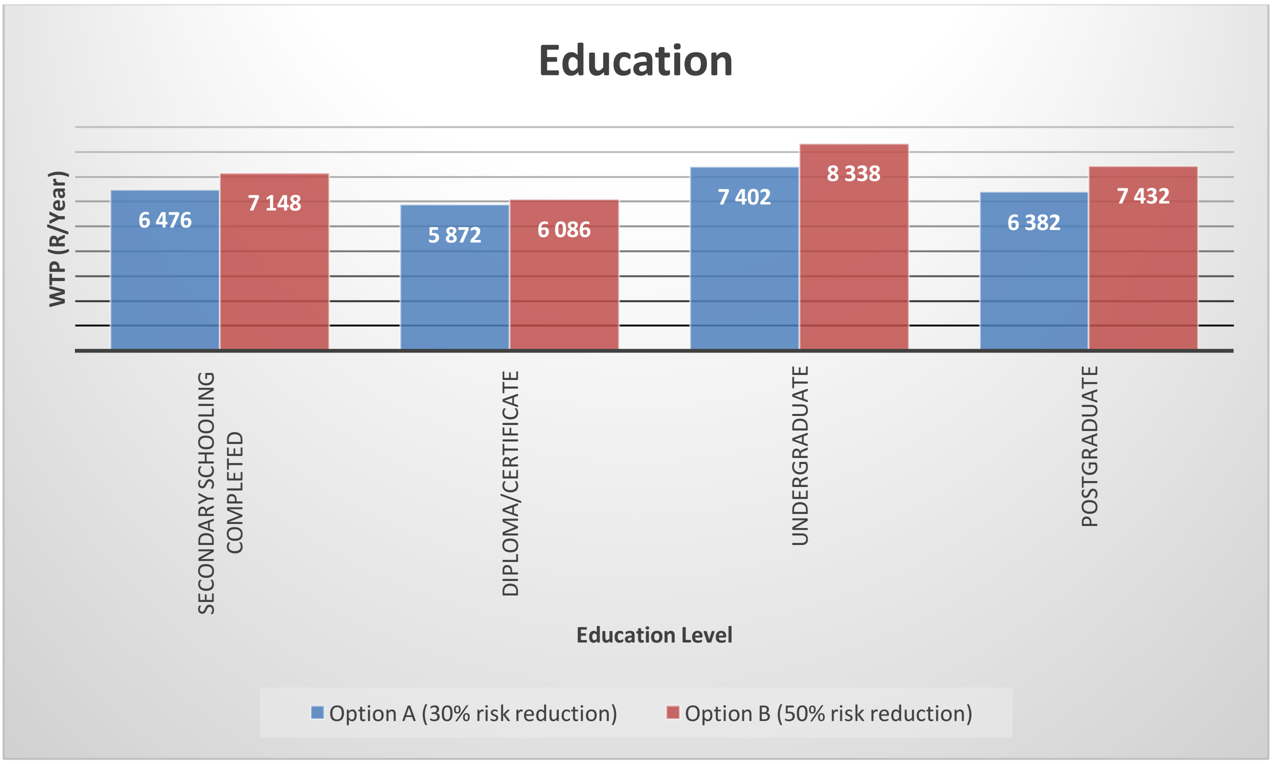


**Figure 5.15: Contingent valuation of respondents' willingness to pay in relation to percentage change in risk level by their education level**

Respondents with bachelor's or first degrees were willing to pay the most to reduce their risk of road injury. However, those with secondary school qualifications and postgraduate qualifications were willing to pay almost similar amounts for both the 30% and 50% reductions in the risk of injury in road crashes. This is evident from Figure 5.15, which shows that for a 30% and 50% risk reduction, respondents with bachelor's or first degrees were willing to pay 12.5% or R926 and 13.8% or R1 020 more than those who had completed secondary schooling and postgraduate qualifications respectively. It is also worth noting that respondents across all the four qualification categories were willing to pay more for a reduction in the risk of road crash injury. Therefore, in this study, education level did not seem to have an influence in WtP behaviour for a reduction in the risk of road traffic injury.

The second secondary objective of this study aimed at investigating empirically the WtPA in the SA context. Furthermore, the third secondary objective of the study was to determine the comparability of the HCA road crash cost estimates and those computed using the WtPA, particularly using the two methods of the latter approach, namely the CVM and the SPM. This section focuses on the application of the former method (the CVM). However, the critical value that needed to be calculated to be able to assess the cost of road traffic crashes using the CVM was the value of preventing a fatality, which is more commonly known as the VoSL (see section 4.5.2.2 for details on the VoSL).

The calculation of the VoSL using CV statistics is therefore presented and discussed below.

*(h) Value of statistical life*

The actual risk of death in a traffic crash in South Africa, derived from the RTMC crash records (see RTMC, 2017), is approximately 249 per million for the year 2017. The 249 fatalities per million is calculated by dividing the total number of 2017 road traffic fatalities (14 050) by the total South African population of 56 521 900 (Stats SA, 2017:8) for the same year and multiplying the quotient by 1 000 000 (i.e. (14 050 ÷ 56 521 900) x 1 000 000). Therefore a 30% reduction in risk (Option A) equals a reduction of 75 per million (30% of 249 per million). To obtain the mean VoSL, the CV mean value of R6 724.50 (see Table 5.8) is multiplied by 1 000 000 ÷ 75, giving a value of R89 660 000.00. The median VoSL calculated by multiplying the median value (R1 850.00 per year) by 1 000 000 ÷ 75 equals R24 666 666.67. For option B, the 50% reduction in risk was equal to a reduction of 124 per million (50% of 249 per million). Multiplying the CV mean value (R7 566.94 per year) by 1 000 000 ÷ 124 gives a mean VoSL of R61 023 709.68. Furthermore, multiplying the CV median value (R3 697.50 per year) by 1 000 000 ÷ 124, gives a median VoSL of R29 818 548.39. The VoSL, based on the median, therefore ranges between R24 666 666.67 and R29 818 548.39.

Cluster analysis results of the CV data are presented and discussed in 5.2.2.5.

#### 5.2.2.5 *Cluster analysis*

In order to place respondents into groups according to their characteristics, cluster analysis was conducted. These clusters made it possible to determine further which characteristics of the respondents had explanatory power of their WtP decisions.

Cluster analysis is an explorative analysis technique that tries to identify structures within the data (Zikmund et al., 2013:597). The purpose of cluster analysis is to maximise heterogeneity between segments (Hair et al., 2010:508; Zikmund et al., 2013:597). Two-step cluster analysis was used in this study. According to Rundle-Thiele et al. (2015:526), two-step cluster analysis allows the simultaneous analysis of both categorical and continuous data, which was highly appropriate in this study where categorical and (self-reported) behavioural data were analysed at the same time. Two-step clustering identifies the groupings by running pre-clustering first and then by using hierarchical methods (Rundle-Thiele et al., 2015:526). Two-step cluster analysis also mechanically selects the number of clusters (Hair et al., 2010:508).

The two-step cluster analysis technique was therefore performed to determine whether distinguishable respondent profiles exist that represent their demographic information and vehicle behaviour characteristics, which could potentially explain their WtP behaviour. In particular, the characteristics and demographic information considered were age, gender, education level, income level, involvement in road crashes in the past, main purpose of travel, car or vehicle ownership, hours travelled per day, level of anxiety or worry about self or family member getting involved in a road crash, and mode of transportation.

The analysis of data identified two clusters. Cluster quality was fair as reported through the silhouette measure of cohesion and separation (average silhouette 0.3) as indicated in Figure 5.16.

**Model Summary**

| | |
|---|---|
| **Algorithm** | TwoStep |
| **Inputs** | 11 |
| **Clusters** | 2 |

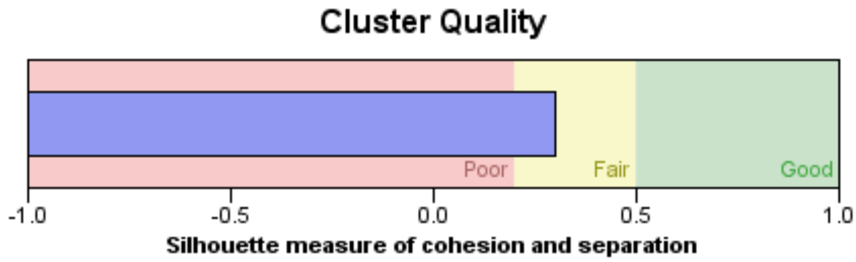


**Figure 5.16: Silhouette measure of cohesion and separation of the different clusters based on benefits sought, respondents' characteristics and demographic profiles**

The cluster analysis identified two clusters, with 69.7% (145) of the respondents grouped in cluster 1 and 30.3% (63) in cluster 2. The characteristics of the two clusters are further detailed in Figure 5.17, which also categorises the clusters by level of importance.

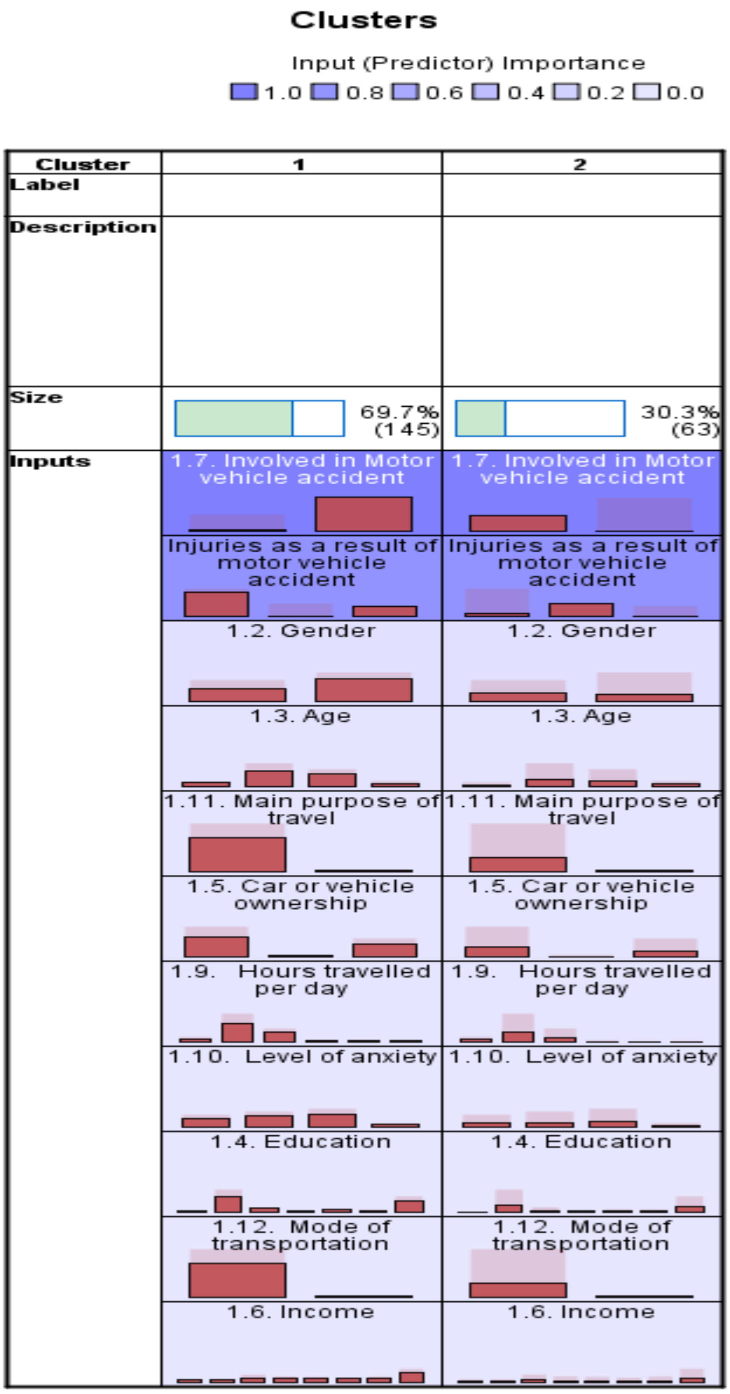


**Figure 5.17: Clusters by input (predictor) importance**

From Figure 5.17, it is evident that the top two elements that were of high importance in forming these clusters were respondents' history of involvement in motor vehicle crash of any type (importance = 1) and whether respondents sustained any injury as a result of a motor vehicle crash (importance = 0.8).

*Cluster 1* represents predominately males, aged between 35 and 44 years old who had been involved in a motor vehicle crash before, and did not sustain any injury as a result of the crash. The majority of them had at least a degree, and the modal category for income was more than R80 000 per month. Their mode of transport was a private vehicle and they owned more than one vehicle. They mostly travelled between 1 and 2 hours per day, and were moderately worried about the risk of being involved in a road traffic crash.

*Cluster 2* consists of predominately females, aged between 35 and 44 years old who had not been involved in a motor vehicle accident before. The injury question was thus, predominately, not applicable. The majority had at least a degree, and the modal category for income was more than R80 000 per month. Their mode of transport was a private vehicle and they owned more than one vehicle. They mostly travelled between 1 and 2 hours per day and were moderately worried about the risk of being involved in a road traffic crash.

Although the two clusters mainly differed with respect to gender, involvement in a vehicle crash and whether injuries had been sustained, it was considered meaningful to include the results as these clusters (in terms of cluster membership) were explored to determine whether their risk behaviour and contingency valuation differed between the two groups. The cross tabulation in Table 5.8 depicts the difference in behaviour regarding the contingency valuation by the two groups.

**Table 5.8: Difference in behaviour regarding contingency valuation by the two groups**

| **Cluster** | **WtP options per day** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **7.4** | **14.79** | **22.19** | **29.59** | **36.99** | **44.38** | **51.78** | **59.18** | **66.58** | **More than 66.58** | **Total** |
| **Option A (30% risk reduction)** | | | | | | | | | | | |
| 1 | 7.6% | 7.6% | 9.7% | 3.4% | 4.8% | 4.1% | 4.8% | 1.4% | 3.4% | 53.1% | 100.0% |
| 2 | 19.0% | 4.8% | 7.9% | 4.8% | 1.6% | 3.2% | 3.2% | 3.2% | 1.6% | 50.8% | 100.0% |
| Total | 11.1% | 6.7% | 9.1% | 3.8% | 3.8% | 3.8% | 4.3% | 1.9% | 2.9% | 52.4% | 100.0% |
| **Option B (50% risk reduction)** | | | | | | | | | | | |
| 1 | 44.1% | 11.0% | 6.9% | 6.2% | 3.4% | 6.2% | 5.5% | 3.4% | 2.1% | 11.0% | 100.0% |
| 2 | 38.1% | 12.7% | 7.9% | 9.5% | 3.2% | 3.2% | – | 1.6% | 4.8% | 19.0% | 100.0% |
| Total | 42.3% | 11.5% | 7.2% | 7.2% | 3.4% | 5.3% | 3.8% | 2.9% | 2.9% | 13.5% | 100.0% |

Table 5.8 indicates that just over 53% of participants within cluster 1 were willing to pay more than R66.58 per day for a 30% risk reduction compared to only 50.8% that are willing to pay the same amount per day for the same risk reduction probability within cluster 2.

Furthermore, 19% of respondents within cluster 2 were willing to pay R7.40 per day for a 30% reduction in the risk of road crash injury compared to only 7.6% of those within cluster 1. There was however, a relative drastic shift in the behaviour of respondents in terms of their willingness to pay for a 50% risk reduction with more respondents in cluster 1 (44.1%) compared to cluster 2 (38.1%) willing to pay R7.40. Furthermore, more respondents in cluster 2 (19%) compared to 11% in cluster 1 were willing to pay more than R66.58 per day. The fact that 53.1% respondents in cluster 1 and 50.8% in cluster 2 were willing to pay more than R66.58 for a 30% risk reduction compared to 11% in cluster 1 and 19% in cluster for a 50% risk reduction, further demonstrates respondents' poor understanding and subsequent interpretation of risk proportions.

The mean, median and SD per group in Table 5.9 show that the cluster consisting mainly of males who had been involved in a road traffic crash in the past but did not sustain any injuries indicate on average a higher WtP amount than the females who had never been involved in a motor vehicle crash.

**Table 5.9: Mean, median and SD per cluster membership**

| Cluster membership | Statistic | WtP: 30% per year risk reduction | WtP: 50% per year risk reduction |
|---|---|---|---|
| 1 | Mean | 4719.2672 | 5234.3973 |
| | Median | 1850.0000 | 3697.5000 |
| | SD | 4323.85803 | 4425.75844 |
| 2 | Mean | 4119.3182 | 4849.5556 |
| | Median | 1850.0000 | 1850.0000 |
| | SD | 4083.93628 | 4430.81472 |
| Total | Mean | 4554.2812 | 5124.0924 |
| | Median | 1850.0000 | 3697.5000 |
| | SD | 4254.97868 | 4416.43356 |

Therefore, contrary to what is shown in Figure 5.14, which indicated that overall, respondents who had never been involved in a motor vehicle crash were willing to pay the most for a reduction in the risk of road traffic injury irrespective of risk probability (i.e. whether it is 30% or 50% risk reduction). This indicates that there are differences in willingness to pay across genders irrespective of whether respondents had been involved in a motor vehicle crash in the past or not.

In order to complete the investigation of the WtPA in the SA context, it was critical to apply the second identified method of the approach in the assessment of road traffic crashes. This second method is the SPM. Therefore, the results of this method are discussed in section 5.2.2.6.

#### *5.2.2.6 Stated preference method*

The second secondary objective of this study intended to investigate the WtPA in the SA context (see section 1.3.2 for secondary objectives). International literature identified two methods of the WtPA, which need to be applied in the assessment of road traffic crashes in this study, namely the CVM and the SPM. However, so far only the CVM has been applied, thus making the assessment incomplete. Furthermore, the incomplete assessment will make the determination of the comparability of the HCA cost estimates and those of the WtPA as envisaged by the third secondary objective of this study incomplete also (see section 1.3.2 for secondary objectives). Therefore, in order to complete the investigation envisaged by the second secondary objective, it was also necessary to apply the SPM.

For the SPM to derive the value of the cost of road traffic crashes, there were three variables of interest: trip cost, travel time and number of fatalities per year. The number of scenarios required was 27 (3x3x3) based on each variable having three levels as shown in Table 5.10. This was clearly too many for a single questionnaire, so it was decided to present nine scenarios to respondents, similar to the approach taken by Le et al. (2011:7).

**Table 5.10: Example of questionnaire scenarios**

| **Respondent Number** | **1** | **Scenario (of 9)** | **1** |
|---|---|---|---|
| | **Choice Game** | | |
| | **Route A** | | **Route B** |
| Cost (in rand) | 19 | | 28 |
| Travel time in busy conditions (in minutes) | 20 | | 45 |
| Number of fatalities per year | 42 | | 27 |
| Given this choice I would choose | A | | B |

In order for the designs to be robust it was important that they contained a good range of trade-offs and that the implied boundary values covered a good range as well (Abdallah et al., 2016:16). A boundary value is the value of which the utility between two modes is exactly the same (Abdallah et al., 2016:16), and it was calculated for each scenario presented. Furthermore, it was important to ensure that the variables were combined such that there were low correlations between them, otherwise multi-collinearity would result leading to estimation problems (Abdallah et al., 2016:15). Multi-collinearity causes redundant information, meaning that what a variable explains about a response is overlapped by what another regressor or a set of regressors explain (Yoo, Mayberry, Bae, Singh, Peter & Lillard, 2014:9). Furthermore, as multi-collinearity increases, it becomes increasingly difficult to ascertain the effect of any single variable and this produces biased estimates of coefficients for regressors because the variables have more interrelationships (Yoo, et al, 2014:9).

According to Abdallah et al. (2016:15), the standard procedure for determining how the different variables are combined is to use ‘orthogonal’ designs. An orthogonal design is a design where the correlation between variables or regressors is zero (Abdallah et al., 2016:15; Paul, 2014:n.p.). According to Rose, Bain and Bliemer (2011, cited in Bennett, 2011:280):

> Historically, by far the most commonly used experimental design type used in stated choice studies has been orthogonal designs. The concept of orthogonality is related to the correlation structure between the attributes of the experimental design, with designs that display no correlations being called orthogonal designs. By forcing the columns of an array to display zero correlations, each column of the design will act independently of all other columns.

However, in some situations, the variables are nearly perfectly linearly related, which is what is referred to as multi-collinearity (see Paul, 2014:n.p.), and in such cases, the inferences based on the regression model can be misleading and erroneous (Paul, 2014:n.p.).

The boundary values used in the research designs were based on the 2017 costs, number of fatalities and estimated travel time for the three routes considered, namely e-tolled portions of N1 (Johannesburg Metropolitan Municipality), N3 (Ekurhuleni Metropolitan Municipality) and N12 (Ekurhuleni Metropolitan Municipality). The estimated time levels were selected as realistic as possible to respondents’ travel experiences. The journey time of interest was the in-vehicle time, which was the overall door-to-door journey time minus any wait or walk time.

The trip costs were calculated based on real e-toll costs respondents are required to pay as they travel on the selected road network (SANRAL, 2017). The number of fatalities per year was the exact number of fatalities the two metropolitan municipalities recorded for the selected routes for the year 2017 as provided by Sintel, a private company the two municipalities contracted to record their road crash statistics (Ekurhuleni Metro Police Department [EMPD], 2018; Johannesburg Metropolitan Police Department [JMPD], 2018).

The purpose of this experiment was to derive a value of willingness to pay per trip by individuals to reduce the number of fatalities. Since the fatal crash casualty rates were presented as a number per year, the value of risk reduction for a fatality was determined by multiplying the willingness to pay by the average annual traffic using the selected routes in a year. According to Abdallah et al. (2016:16), this approach is based on previous studies by Hojman, De Dios Ortúzar and Rizzi (2005) and Le et al. (2011).

The modelling used to analyse the SP data utilised the binary logistic regression model (see Meyers et al., 2013) as the discrete choice was based on two options. The multinomial logistic regression (see Meyers et al., 2013) was conducted as a confirmatory mechanism regarding the coefficients, similar to the modelling as conducted by Abdallah et al. (2016:16). The resulting coefficients were identical. SP data with 999 observations were used in the analysis.

Following are the results of the binary logistic regression analysis.

*(a) Binary logistic regression analysis*

In order to determine model relationships between the three independent variables of interest in this study, namely cost, travel time and fatalities, and willingness to pay or route choice, multinomial logistic (MNL) regression analysis and binary logistic regression analysis were performed. However, the results for both the MNL model and the binary logit model were exactly the same, as the experiment only involved two choices. Only the results of the binary logistic model are presented in this section. Amongst others, as recommended by Meyers et al. (2013:541), the following tests were used in this study to evaluate the viability of the model:

- -2 log likelihood ratio (see Meyers et al., 2013);
- omnibus chi-square (see Meyers et al., 2013);
- pseudo $R^2$ (see Meyers et al., 2013); and
- Wald test of significant coefficients (see Meyers et al., 2013).

Table 5.10 provides the omnibus tests of model coefficients (see Meyers et al., 2013) giving a Chi-Square of 514.214 on 1 degree of freedom (df), with p-value =.000. This is a test of the null hypothesis that adding the cost, time and fatalities variables to the model has not significantly increased the ability of the model to predict the decisions made by respondents on route choices. The omnibus tests of model coefficients therefore describe the significance of the model (see Meyers et al., 2013). The fact that the p-value was less than .01 indicated that the null hypothesis that adding the cost, time and fatalities variables to the model has not significantly increased the ability of the model to predict the decisions made by respondents on route choices could be rejected. Therefore, rejecting the null hypothesis imply that the three predictors (cost, time and fatalities) that were added improved the prediction power of the model.

**Table 5.11: Omnibus tests of model coefficients**

| | | Chi-square | Df | Sig. |
|---|---|---|---|---|
| Step 1 | Model | 514.214 | 3 | .000 |

Table 5.11 therefore shows that adding the three variables (cost, time and fatalities) to the model had actually increased the ability of the model to predict the decisions made by respondents significantly.

The model summary presented in Table 5.12 shows that the -2 log likelihood statistic was 870.252. The smaller the statistic the better the model (see Meyers et al., 2013). Adding the three variables to the model reduced the -2 log likelihood statistic by the chi-square in Table 5.10 from 1384.466 to 870.252 as shown in Table 5.12.

**Table 5.12: Model summary**

| Step | -2 log likelihood | Cox and Snell R-square (Meyers et al., 2013) | Nagelkerke R-square (Meyers et al., 2013) |
|---|---|---|---|
| 1 | 870.252[a] | .402 | .537 |

As it is evident from Table 5.12, the Cox and Snell $R^2$ = .402 and Nagelkerke $R^2$ = .537. These are both pseudo R-square values. This therefore, further indicates that adding the three variables improved the model.

In order to determine the percentage of the cases whose group membership was correctly classified, classification table results were determined (Meyers et al., 2013:543). The results are summarised in Table 5.13 showing that the percentage classification of Model 1 was 96% compared to the 51.1% of Model 0, a percentage change improvement of 88.8%.

**Table 5.13: Classification table[a]**

| | | | Predicted | | |
|---|---|---|---|---|---|
| | | | Route | | Percentage correct |
| **Observed** | | | **A** | **B** | |
| Step 1 | Route | A | 449 | 40 | 91.8 |
| | | B | 0 | 510 | 100.0 |
| | Overall percentage | | | | 96.0 |

*a. The cut value is .500*

Furthermore, there was a need to test the statistical significance of the unique contribution of each coefficient (B) in the model. Subsequently, the Wald test of significant coefficients was done. Table 5.14 presents the results, and it shows that the coefficients of the variables cost, time and fatalities are indeed significant ($p = .000 < .01$). These coefficients indicate the amount of change expected in the log odds when there is a 1-unit change in any one of the predictor variables with all the other variables in the model held constant (Meyers et al., 2013:541).

**Table 5.14: Variables in the equation**

| | | B | S.E. | Wald | df | Sig | Exp(B) |
|---|---|---|---|---|---|---|---|
| Step 1[a] | Cost | .225 | .018 | 160.539 | 1 | .000 | 1.252 |
| | Time | -.052 | .008 | 44.665 | 1 | .000 | .950 |
| | Fatalities | -.104 | .015 | 46.417 | 1 | .000 | .901 |
| | Constant | -.753 | .840 | .805 | 1 | .370 | .471 |

*a. Variables entered on step 1: cost, time, fatalities.*

It needs to be indicated that a coefficient (B) close to 0 suggests that there is no change due to the predictor variable (Meyers et al., 2013:541). Therefore, the fact that the coefficient of the predictor variable 'time' is the closest to 0 means that its effect on the model was minimal. Furthermore, since the coefficient of the predictor variable 'cost' was the furthest (from 0) of the three variables considered in this study shows that this variable made the biggest contribution towards the viability of the model.

*(b) Calculation of the VoSL using the binary regression model parameters*

Table 5.15 shows the estimated model for vehicle users. As is evident from Table 5.15, all the parameters are significant. The goodness of fit as measured by rho-squared was .537, which indicates acceptable fit.

**Table 5.15: Vehicle user model**

| Variables | Parameter | S.E. | Wald | Sig. |
|---|---|---|---|---|
| Cost | .225 | .018 | 160.539 | .000 |
| Time | -.052 | .008 | 44.665 | .000 |
| Fatalities | -.104 | .015 | 46.417 | .000 |
| **Number of observations** | | 999 | | |
| **Number of individuals** | | 142 | | |
| **Null log likelihood** | | 1321.466 | | |
| **Final log likelihood** | | 807.252 | | |
| **Rho-square** | | .537 | | |

The values for avoided fatal injury casualties were derived by dividing the relevant fatalities parameter in Table 5.15 by trip cost parameters, as shown in Table 5.16.

**Table 5.16: Value for avoided fatal injury casualties**

| Cost (in rand) | Value | S.E. |
|---|---|---|
| Value of an avoided fatality (per trip) | 0.462 | 0.24 |

Estimates of the VoSL were obtained by multiplying the WtP values per trip, as reflected in Table 5.15 by the average annual traffic volume on the road network as estimated using the 2017 traffic volumes data provided by the SANRAL. The average weekday traffic on the three routes considered for this study was calculated to be 64 110 vehicles per weekday. This equates to an average annual traffic volume of 16 027 500 obtained by multiplying the average weekday traffic (64 110) by 250 working days in a year. The VoSL (avoided fatality) is therefore estimated as R7 404 705, and this figure will be used to calculate the cost of life loss as a result of road traffic crashes for both the 30% and the 50% reduction in the risk of road traffic crash injury.

Table 5.17 shows the calculation of the cost of life loss as a result of traffic crashes for a 50% reduction in the risk of road crash injury using the CVM. The overall cost of life loss reflected in Table 5.17 was used to calculate the upper bound of the range within which the road traffic crash cost estimate will be when using the CVM.

**Table 5.17: The cost of life loss as a result of traffic crashes: CVM (50% risk reduction)**

| Year | Population | Number of road fatalities | VoSL (in rand) | Overall cost of life loss (in rand) |
|---|---|---|---|---|
| 2017 | 56 717 156 | 14 050 | 29 818 548.39 | 418 950 604 879.50 |

Table 5.18 shows the cost of life loss resulting from motor vehicle crashes calculated using the CVM for a 30% reduction in the risk of getting involved in a motor vehicle crash. The overall cost of life loss reflected in Table 5.18 was used to calculate the lower bound of the range within which the road traffic crash cost estimate would be when using the CVM.

**Table 5.18: The cost of life loss as a result of traffic crashes: CVM (30% risk reduction)**

| Year | Population | Number of road fatalities | VoSL (in rand) | Overall cost of life loss (in rand) |
|---|---|---|---|---|
| 2017 | 56 717 156 | 14 050 | 24 666 666.67 | 346 566,666 713.50 |

As Tables 5.17 and 5.18 show, the 2017 total cost of road traffic crash-related life loss in South Africa calculated using the CVM ranged between R346 566 666 713.50 and R418 950 604 879.50. However, as Table 5.19 shows, if the SPM is used for this purpose, the 2017 cost of life loss as a result of road crashes in South Africa is R104 036 105 250.

**Table 5.19: The cost of the life loss as a result of traffic crashes: SPM**

| Year | Population | Number of road fatalities | VoSL (in rand) | Overall cost of life loss (in rand) |
|---|---|---|---|---|
| 2017 | 56 717 156 | 14 050 | 7 404 705 | 104 036 105 250 |

In line with Mohamed's (2015:56) ratios, for the purpose of this study, the calculation of the cost of serious injuries, minor injuries and damages or other incidents was based on the following guidelines:

- the value of serious injury loss was estimated by 10.0% of the value of lost life;
- the value of a minor injury was estimated by 1.0% of the value of the lost life; and
- the value of property damage only resulting from a car crash was estimated at 0.1% of the value of the lost life.

Furthermore, Labuschagne (2016:32) reports the following ratios in terms of the number of injuries to fatalities:

- serious injuries to fatalities was estimated at 4.6:1;
- minor injuries to fatalities was estimated at 14.9:1; and
- property damage only (i.e. no human injuries) to fatalities was estimated at 105.2:1.

These percentages and ratios were respectively used for the purpose of this study to estimate the cost estimates and number of serious and slight injuries as well as property damage only crashes for use in calculating cost estimates for these crash severity categories. As envisaged by the second secondary objective of this study, calculation of crash cost estimates using the SPM enabled us to conclude the investigation of the WtPA within the SA context by computing road traffic cost estimates using the two methods of the WtPA, namely the CVM and the SPM (see section 1.3.2 for secondary objectives). Furthermore, it enabled us to determine the comparability of the HC cost estimates and the two WtP cost estimates that were calculated using the two methods as envisaged by the third secondary objective of this study (see section 1.3.2 for secondary objectives).

It therefore follows that if we consider the 2017 ranges of cost of life loss as a result of traffic crashes calculated using the CVM (i.e. ranges between R346 566 666 713.50 and R418 950 604 879.50) that the cost of road crashes in South Africa according to the 2017 statistics ranges between R595 688 580 963.48 and R718 165 128 512.30 as shown in Tables 5.20 and 5.21 resulting in a per capita GDP[43] loss of between R10 539 and R12 706 if the 2017 population size of 56 521 900 is considered (Stats SA, 2017:2). Therefore, according to the CVM, the percentage of cost of road crashes to GDP in South Africa ranged between 19.1 and 23.0% of South Africa's 2017 GDP of R3 124 887 trillion (Stats SA, 2018a:8).

[43] GDP per capita or per capita GDP is GDP divided by mid-year population of a country (World Bank, 2009:19).

**Table 5.20: The cost of road crashes in South Africa according to 2017 statistics (CVM) (50% risk reduction)**

| Statement | Number | The value of the accident cost in South Africa | The total cost (in rand) | Percentage of all accidents total cost (%) |
|---|---|---|---|---|
| Fatalities | 14 050 | 29 818 548.39 | 418 950 604 879.50 | 58.3 |
| Serious injuries | 64 630 | 2 981 854.84 | 192 717 278 309.20 | 26.8 |
| Minor injuries | 209 345 | 298 185.48 | 62 423 639 310.60 | 8.7 |
| Property damage only | 1 478 060 | 29 818.55 | 44 073 606 013.00 | 6.1 |
| **Total** | | | **718 165 128 512.30** | **100** |

Table 5.21 shows the calculation of the 2017 cost of road crashes in South Africa for a 30% risk reduction applying the CVM on the 2017 road crash statistics.

**Table 5.21: The cost of road crashes in South Africa according to 2017 statistics (CVM) (30% risk reduction)**

| Statement | Number | The value of the accident cost in South Africa | The total cost (in rand) | Percentage of all accidents total cost (%) |
|---|---|---|---|---|
| Fatalities | 14 050 | 24 666 666.67 | 335 244 666,711.97 | 56,3 |
| Serious injuries | 64 630 | 2 666 666.67 | 172 346 666 882.10 | 29.0 |
| Minor injuries | 209 345 | 246 666.67 | 51 638 434 031.15 | 8,7 |
| Property damage only | 1 478 060 | 24 666.67 | 36,458,813,338.26 | 6.1 |
| **Total** | | | **595 688 580 963.48** | **100** |

Table 5.21 shows that the lower bound of the range within which the cost of road traffic crashes fall is R595 688 580 963.48.

However, if the 2017 cost of life loss as a result of traffic crashes is calculated using the SPM (R104 036 105 250), the cost of 2017 road crashes in South Africa is R178 338 691 619.55 as shown in Table 5.22, which equals 5.7% of South Africa's 2017 GDP[44] of R3 124 887 trillion (Stats SA, 2018a:8), and this figure also translates into R3 155.21 per capita GDP annual loss if the 2017 population size of 56 521 900 is considered (Stats SA, 2017:2).

[44] Gross domestic product (GDP) is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output (World Bank, 2009:17).

**Table 5.22: The cost of road crashes in South Africa according to 2017 statistics (SPM)**

| Statement | Number | The value of the accident cost in South Africa | The total cost (in rand) | Percentage of all accidents total cost (%) |
|---|---|---|---|---|
| Fatalities | 14 050 | 7 404 705 | 104 036 105 250 | 58.3 |
| Serious injuries | 64 630 | 740 470.50 | 47 856 608 415 | 26.8 |
| Minor injuries | 209 345 | 74 047.05 | 15 501 379 682.25 | 8.7 |
| Property damage only | 1 478 060 | 7 404.71 | 10 944 598 272.30 | 6.1 |
| **Total** | | | **178 338 691 619.55** | **100** |

The cost estimate of road crashes calculated using the SPM of the WtPA clearly falls outside the range of the CVM. This is contrary to findings by previous similar studies (Le et al., 2011:12).

## 5.3 CONCLUSION

Chapter 5 aimed at achieving two of the four secondary objectives of this study, namely the second secondary objective (to investigate the WtPA in the SA context empirically) and the third secondary objective (to determine the comparability of the cost estimates of the HCA and the WtPA) (see section 1.3.2). In line with the second secondary objective of this study, the chapter reports on an investigation of the WtPA in the SA context by applying two methods of this approach, namely the CVM and the SPM. Once 2017 cost estimates had been computed using the two methods, they were then compared with the 2017 HCA cost estimates that were obtained by adjusting the 2016 cost estimates for inflation using a 5.3% 2017 inflation rate. The comparison was intended to determine the comparability of the HCA cost estimates to those calculated using the WtPA as envisaged by the third secondary objective of this study (see section 1.3.2 for secondary objectives of this study). In order to group respondents by their demographic characteristics, cluster analysis was conducted. The purpose of grouping the respondents this way was to be able to determine WtP behaviour of each group identified and also to compare the WtP behaviours of the groups.

Cluster analysis identified two clusters, with 69.7% (145) of the respondents grouped in cluster 1 and 30.3% (63) in cluster 2. The two elements that were of high importance in forming these clusters were respondents' history of involvement in motor vehicle crashes of any type (importance = 1) and whether respondents had sustained any injury as a result of a motor vehicle crash (importance = 0.8). Cluster 1 consisted of predominately males, aged between 35 and 44 years old who had been involved in a motor vehicle crash before and who did not sustain any injury as a result of the crash. The majority of them had at least a degree and their modal category for income was more than R80 000 per month, their mode of transport was a private vehicle and they owned more than one vehicle. They mostly travelled between 1 and 2 hours per day and they were moderately worried about the risk of being involved in a crash. Cluster 2 consisted of predominately females, also aged between 35 and 44 years of age who had not been involved in a motor vehicle crash before. As a result, the injury question was predominately not applicable to them. Just as in the case of cluster 1, the majority of them had at least a degree and their modal category for their income was more than R80 000 per month. Their mode of transport was also a private vehicle and they also owned more than one vehicle. Furthermore, they also mostly travelled between 1 and 2 hours per day and they were also moderately worried about the risk of getting involved in a road traffic crash. Further analysis of the clusters shows that the cluster consisting mainly of males who had been involved in a crash in the past but did not sustain any injuries indicated on average, a higher WtP amount than the females who had never been involved in a motor vehicle crash. This gives a different perspective to contingent valuation of willingness to pay, which showed that overall, respondents who had never been involved in a motor vehicle crash were willing to pay the highest amounts. It therefore shows that this was not necessarily the case with female respondents in the sample of this study.

The CVM revealed that while respondents were willing to pay for a reduction in the risk of being killed in a road traffic crash, they seemed to be unable to differentiate between probabilities of being involved in a crash. This resulted in a wide range for the VoSL calculated using this method, R29 818 548.39 – R24 666 666.67 = R5 151 881.72 for the two risk reduction percentages considered (50% and 30%). The costs of crashes calculated using the WtPA confirmed the assertion of previous studies that cost estimates calculated using the WtPA are much higher than those obtained through the HCA. The research on which the study is based found that when using the CVM of the WtPA, the total cost of crashes ranges between R595 688 580 963.48 and R718 165 128 512.30 whereas the SPM yields a total cost of R178 338 691 619.55. Therefore, the CV cost estimate ranged between 3.96 to 4.77 times the cost calculated using the HCA (that is R150 526 965 936) whereas the SP cost estimate was 1.18 times more than the same figure. It is therefore evident that both the CV and SP cost estimates were more than the HCA cost estimate. This confirms the assertion of previous studies that the HCA underestimates the cost of road traffic crashes.

Furthermore, contrary to findings of a similar study by Le et al (2011:12), this study found the VoSL figure derived from the SP survey data (R7 404 705) to be outside and far below the range obtained using the CVM, i.e. R24 666 666.67 and R29 818 548.39. This could be attributed to the knowledgeable purposive sample of participants, which skewed choices in terms of what respondents are willing to pay thus skewing results as is evident from the high means in Table 5.7.

The next chapter discusses the findings of the study and provides recommendations on road crash cost assessment practices to be used in future SA studies.

# CHAPTER 6:
# CONCLUSIONS AND RECOMMENDATIONS FOR ROAD TRAFFIC CRASH COST ASSESSMENT IN SOUTH AFRICA

## 6.1 INTRODUCTION

Chapter 1 emphasised that road traffic crashes are an economic, health and social burden to society in any country and this is especially true in the case of developing countries (Abdallah et al., 2016:10; Alrukaibi et al., 2015:46; Bora et al., 2018:1275; Iragüen & De Dios Ortùzar, 2004:513; Kittelson, 2010:1; Mohamed, 2015:43; Pėrez-Nûńez et al, 2012:69; Rizzi & De Dios Ortúzar, 2006b:471; Yusoff et al., 2013:1) of which South Africa is one. This therefore makes a strong case for a need to make scientifically sound road safety investment decisions based on cost-effectiveness and cost–benefit analyses considering that economic resources are limited (Bhalla, 2013:8; Bliss & Breen, 2009:11; Mohamed, 2015:43; Wijnen & Stipdonk, 2016:97). Review of literature on the assessment of the cost of road traffic crashes in South Africa established that from 2003 to 2014, no study was conducted to update the estimates of the cost of road traffic crashes in the country. Furthermore, despite international literature advocating for the use of the WtPA to assess the cost of road traffic crashes, only the HCA was used in all the studies commissioned by the DoT to assess the cost of crashes in South Africa conducted from 1965 to 2016 (See Burton & Eksteen, 1967; Cillié, 1975; Cillié and Freeman, 1977; De Beer & Van Niekerk, 2004; De Haan, 1992; De Vos & Burton, 1965; Glass & Hamilton, 1987; Goosen, 1980; Goosen & Kolman, 1982; Labuschagne, 2016; Morden, 1989; Schutte, 2000; Verburgh et al., 1985).

In order to address the challenge briefly discussed above, the primary objective of this study was therefore to propose a hybrid framework for assessing the cost of road traffic crashes in South Africa (see section 1.3.1). The primary objective was to be achieved by achieving four secondary objectives of this study, namely to:

- provide a literature review on international best practice in the assessment of the cost of road traffic crashes;
- investigate the WtPA empirically in the SA context;
- determine the comparability of the road traffic cost estimates of the HCA and the WtPA; and
- structure the components of and the relationship between the HCA and the WtPA.

The purpose of this chapter is therefore to provide a summary of the findings of this study and also to make recommendations on the use of a hybrid framework in the assessment of the costs of road traffic crashes in South Africa. It should be reiterated though that the cost estimates provided in this study cannot be generalised for the South African population since they were calculated as an illustration of the application of the hybrid framework proposed in this study rather than a real case at hand. The chapter also provides a summary of how each of the four secondary objectives of the study was achieved. The chapter further explains the contribution of the study to the body of knowledge and makes recommendations on components that should constitute the hybrid framework for the assessment of the cost of road traffic crashes proposed by the study. Limitations of the current study and recommendations for future research are provided in this chapter as well.

Chapter 1 reported on global road safety challenges associated with road crashes that resulted in injuries and fatalities. Road traffic injuries are identified as both a public health problem and a developmental issue. De Leon et al. (2005:3183), amongst others, assert that motor vehicle crashes are a health, social, and economic problem because:

- the health sector would have to stretch its bed capacity in order to care for victims while still overseeing other important illnesses;
- families are displaced and their future ruined as a result of the sudden death of their breadwinners, which is a social welfare problem; and
- road crashes lay off workers, which eventually translates to millions of rand of potential lost productivity thereby affecting domestic production and the economy at large.

Abdallah et al. (2016:10) further indicate that over 91% of the world’s road fatalities occur in low- and middle-income countries, which only contribute about 50% of the world’s vehicle population. The high road crash injury rates in developing countries are the result of booming economies culminating in increased motorisation mainly due to increasing per capita income and increasing urbanisation and the fact that ‘road systems’ in these countries are far from mature (Abdallah et al., 2016:10; Bener, 2005:45; Hyder & Vecino-Ortiz, 2014:423; Rizzi & De Dios Ortúzar, 2006b:473; WHO, 2015:ix). Furthermore, in line with global trends, South Africa lost 3.4% of the country’s GDP to road crashes in 2015 (Bhalla, 2013:8; Labuschagne, 2016:ii; Mohan, 2002:4).

Despite the dire consequences of road crashes outlined in the previous paragraphs, Abdallah et al. (2016:10) assert that many of the road crashes are preventable and by preventing them, society increases the supply of scarce resources that can be used to increase income and improve welfare.

Chapter 2 provided a review of the literature on international good practice on the assessment of road traffic crash costs as envisaged by the first secondary objective (to provide a literature review on international best practice in the assessment of the cost of road traffic crashes) of this study. The literature review guided the identification of components of and relationships between the HCA and the WtPA. This made it possible to achieve the fourth secondary objective by structuring the components of and the relationship between the HCA and the WtPA (see section 1.3.2). Seven countries were selected for this purpose, namely Australia, Belgium, Egypt, the Netherlands, Singapore, the United Kingdom and the United States of America. These countries were selected because of their outstanding road safety performance and/or good practice in the valuation of the costs of road traffic crashes. In particular, the literature review identified three critical areas of good practice, namely cost categories, road traffic crash cost severity as well as cost components. These areas of good practice are discussed in detail under the conclusions and recommendations on the findings of the study in section 6.2.

Chapter 3 reviewed eight SA road traffic cost assessment studies to provide an SA perspective building upon the literature reviewed in Chapter 2. This was intended to compare SA road traffic crash cost assessment practices to international practices in order to identify gaps if any. In case gaps were identified, whether in terms of approaches used or components, recommendations will be made to replicate practices from international studies to enhance SA cost assessment practice.

Chapter 4 synthesised the findings of the literature reported in Chapters 2 and 3 to identify practices that were applied in this study and also to make recommendations for future similar studies in South Africa. In particular, the synthesis resulted in the identification and recommendation of approaches and methods applied in this study. Specifically, this study recommends the use of the HCA and the WtPA in the assessment of road traffic crash costs in South Africa. Two methods of the WtPA are recommended for use in the assessment of road traffic costs in South Africa, namely the CVM and the SPM. The application of these approaches and methods achieved two of the four secondary objectives of this study, namely the second (to investigate the WtPA empirically in the SA context) and third (to determine the comparability of the cost estimates of the HCA and the WtPA) secondary objectives (see section 1.3.2).

In Chapter 5, a discussion of the application of the two approaches recommended in Chapter 4 to assess the costs of road traffic crashes is provided, namely the HCA and the WtPA. The application of the latter is done by using the two recommended methods, namely the CVM and the SPM. Through this process, the second secondary objective of this study was achieved by investigating the WtPA empirically in the SA context resulting in cost estimates calculated using the two methods. For purposes of the HCA, the 2016 estimates of the cost of road traffic crashes were adjusted for inflation using a 5.3% inflation rate to obtain 2017 cost estimates. Once the cost estimates had been calculated for the two approaches, comparability of the cost estimates of the two approaches was determined thus achieving the third secondary objective (to determine the comparability of the cost estimates of the HCA and the WtPA) (see section 1.3.2).

Figure 6.1 depicts the outline of this chapter in terms of the different sub-sections that reflect the reporting of the results.

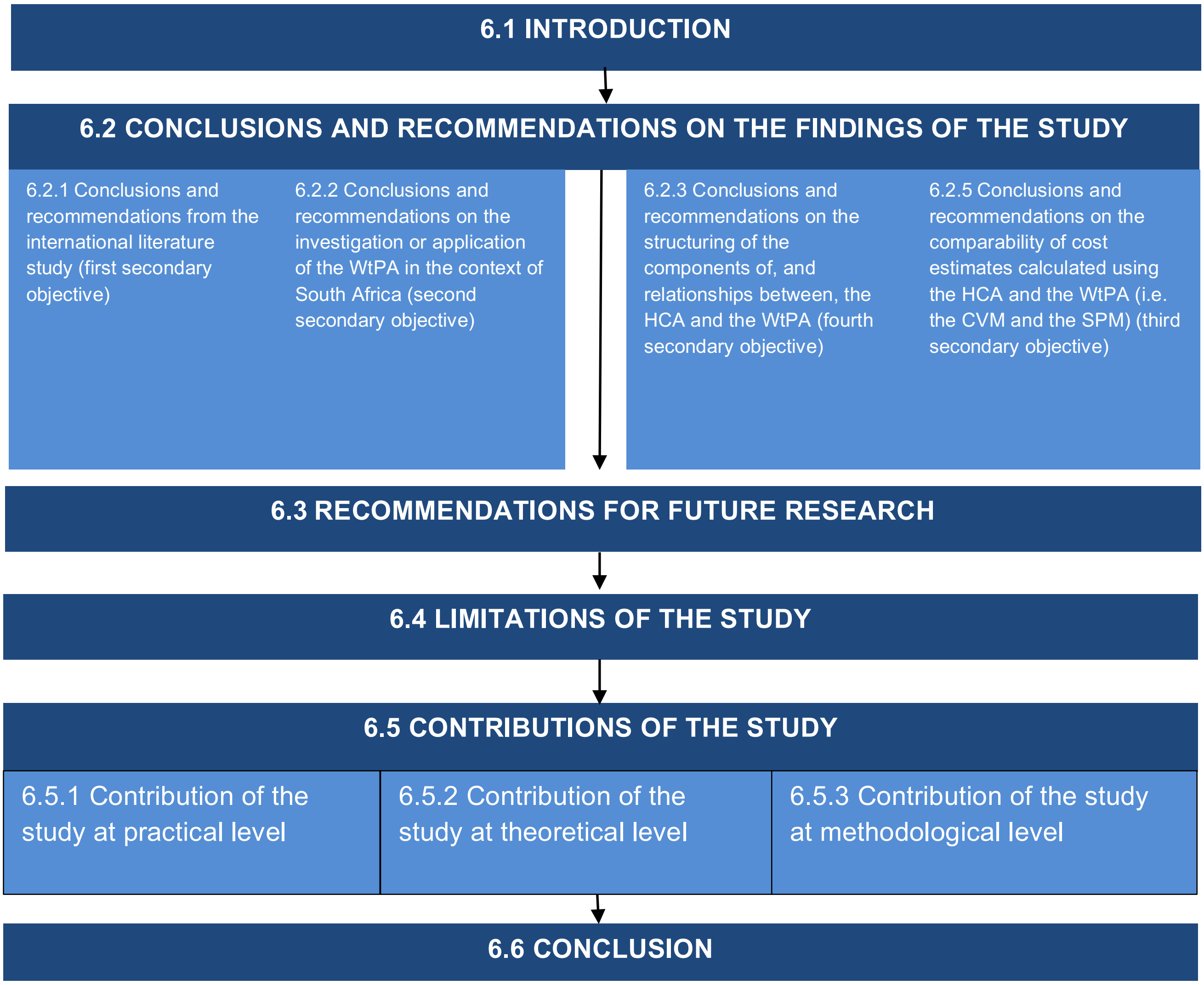


**Figure 6.1: Diagrammatic representation of the outline of Chapter 6**

As Figure 6.1 illustrates, the chapter started with an introduction to the section outlining the objectives of this study first. The introduction also explained what each chapter entailed and how they contributed towards the achievement of each of the four secondary objectives of this study and therefore the achievement of the primary objective as well. The introduction is followed by conclusions and recommendations on findings related to each of the four secondary objectives. These are discussed in section 6.2. The conclusions and recommendations on findings related to each of the four secondary objectives are followed by recommendations for future research in section 6.3. Before the conclusion of the chapter in section 6.6, limitations and contributions of the study are discussed in sections 6.4 and 6.5 respectively.

Conclusions and recommendations on the findings of the study are discussed in the next section.

## 6.2 CONCLUSION AND RECOMMENDATIONS ON THE FINDINGS OF THE STUDY

The primary objective of this study was to propose a hybrid framework for assessing the costs of road traffic crashes in South Africa. This study achieved the primary objective by realising four secondary objectives, namely to:

a. provide a literature review on international best practice in the assessment of the cost of road traffic crashes;
b. investigate the WtPA empirically in the SA context;
c. determine the comparability of the cost estimates of the HCA and the WtPA; and
d. structure the components of, and the relationship between, the HCA and the WtPA.

The following findings and recommendations are therefore based on each of the four secondary objectives concluding by recommending the hybrid framework that was envisaged by the primary objective of this study.

### 6.2.1 Conclusion and recommendations from the literature study (first secondary objective)

The first secondary objective of this study was to provide a literature review on international best practice in the assessment of the cost of road traffic crashes (see section 1.3.2). In order to achieve this secondary objective, a review of international literature was conducted to identify good practice in the assessment of the costs of road traffic crashes in seven selected countries, namely Australia, Belgium, Egypt, the Netherlands, Singapore, the United Kingdom and the United States of America. The findings of the literature review were intended to inform recommendations on how the approach used in South Africa could be improved.

It is evident from literature reviewed that almost all seven countries considered for the review of literature have either moved away from the HCA to adopt the WtPA or they use the WtPA to determine their estimates of human costs for use as a cost component of the HCA (see sub-section 2.3). The literature reviewed revealed that Egypt and Singapore applied the WtPA entirely to assess their road traffic crash cost estimates (Abdallah et al., 2016:10; Le et al., 2011:15) (see section 2.3.2). However, the Netherlands, the United Kingdom, and Belgium use the WtPA to derive the value of human costs for inclusion as a component in assessing costs of road traffic crashes using the HCA (De Brabander & Vereeck, 2007:717; Hendrie & Miller, 2012:24; SWOV, 2012:2–3; Wijnen, 2013). The studies reviewed in this study advocate for a shift to use the WtPA (Giles, 2003:95; Maier et al., 1989:181; Tooth, 2010:4, 7; Wren & Barrell, 2010:15). In support of this shift, Wijnen (2013:3) reports that, according to international guidelines and state-of-the-art economic theory, human costs should be estimated by using a ‘willingness-to-pay’ (WtP) method. The SPM of the WtPA is commonly used for this purpose, and road crash cost assessment studies utilise the CVM and SPM of the WtPA to calculate the VoSL and cost estimates. However, just as in the case of South Africa, which uses the RAF compensation figures as proxies for pain, grief, suffering and loss of amenities of life (human costs), Australia also uses awards from the TAC for this purpose (BITRE, 2009:84; Risbey et al, 2010:3; Tooth, 2010:1; Wren & Barrell, 2010:15). International literature also shows a number of common features in the application of the HCA in the assessment of road traffic costs for the five countries that used this approach, (i.e. Australia, Belgium, the Netherlands, the United Kingdom and the United States of America), namely:

- *Cost categories*: road traffic crash cost valuation studies of four of these five countries divide costs into direct and indirect costs. These countries are the United Kingdom, the Netherlands, Australia and the United States of America (see Tables 2.5, 2.7, 2.9 and 2.12). Direct costs are further divided into direct medical human costs, direct non-medical human costs, direct vehicle costs and direct general costs. Furthermore, indirect costs are also divided into indirect tangible human costs and indirect general costs.
- *Crash severity*: in determining the total costs of road traffic crashes in the United Kingdom, Belgium and Australia, the costs per cost component are disaggregated by crash severity level, that is fatal injury, serious injury, slight injury and property damage only (see Tables 2.13, 2.14 and 2.19). In Australia, these severity levels are referred to as 'fatalities', 'hospitalised injuries', 'non-hospitalised injuries', 'property damage' and 'general costs' respectively (see Table 2.6).
- *Cost components*: there are seven cost components that are common across at least two of the five countries discussed above in terms of the cost components considered in the assessment of their road crash traffic costs, namely property damage costs, medical costs, congestion costs, production loss, legal costs, insurance administration and human costs.

Eight SA studies were reviewed in Chapter 3 to establish whether there are any improvements that need to be effected on the approaches and methods used in South Africa. The review of SA studies found that despite the strong international advocacy for a shift to the WtPA, all the studies conducted used the HCA. Furthermore, the following cost components were found to be common across all these studies: loss of output costs, property damage costs, medical costs, human costs, legal costs and administrative costs.

Approaches, methods and components that were found to be used in the international literature reviewed for the purpose of this study that are not included in any of the eight SA studies also reviewed for the purpose of this study were applied in this study and are also included as part of the hybrid framework recommended for use in future studies.

### 6.2.2 Conclusions and recommendations on the investigation or application of the WtPA in the context of South Africa (second secondary objective)

In this study, the cost estimates calculated using the CVM far exceed those of SPM (see Tables 5.19, 5.20 and 5.21). As findings of previous studies show, this is not an uncommon finding. This could arguably be partly attributed to the different scenarios and assumptions used in the two techniques as well as a possibility of respondents having interpreted the designs differently. Mogas, Riera and Bennett (n.d.:1) however report that the two techniques were found to yield equivalent estimates when the fully specified utility functions are used as the basis for the calculations. For example, when elements of the utility functions such as the alternative specific constants and the socio-demographic variables are omitted from the value estimation procedure, significant differences do occur between estimates that are derived using the two valuation techniques (Mogas et al., n.d.:1). However, Hanley, Mourato and Wright (2001:450) assert that the only consistent case where CV estimates are higher than estimates from other preference techniques and real payment experiments can be found where the values result from voluntary contributions. This is because voluntary contributions give respondents the incentive to overbid in the hypothetical market while free riding in terms of actual payments (Hanley et al., 2001:450). Furthermore, Abelson (2008:8) indicates that the problem with CV research is that individuals find it hard to provide accurate responses to direct WtP questions (such as the amount in rand one would be willing to pay for X), especially for unfamiliar options and small changes in risks. On the other hand, the provision of monetary cues, as was the case in this study, such as a list of possible amounts in rand for respondents to choose from tends to bias the results (Abelson, 2008:8).

Mogas et al. (n.d.:10) also found that the SPM is superior to the CV estimation in terms of the goodness of fit (pseudo-$R^2$); thus, suggesting that the SPM has a greater capacity to explain the choices made by respondents. This could in part be attributed to the fact that SP choices are explained in terms of variations in multiple attributes, such as respondents' socio-demographic characteristics and interactions between these variables, whereas CV responses can only be explained in terms of one attribute, which is cost, and the socio-economic characteristics (Mogas et al., n.d.:10). In support of this assertion:

- Admowicz, Boxall, Williams and Louviere (1998:65) conclude that the appeal of the SPM in economic analysis is that it is based on random utility theory and it is a generalisation of the CVM in the sense that rather than asking people to choose between a base case and a specific alternative, the SPM asks respondents to choose between cases that are described by attributes.

- Hanley et al. (2001:435) also report that SPMs are consistent with consumer theory and their focus is on an attribute-based theory of value, which permits a superior representation of many management contexts.

Therefore, it is recommended that even if the hybrid framework includes the CVM cost estimates, recommendations and comparison with the HCA cost estimates should use the SPM estimates.

### 6.2.3 Conclusions and recommendations on the comparability of cost estimates calculated using the HCA and the WtPA (third secondary objective)

This study calculated estimates of road crash costs using two different approaches, namely the HCA and WtPA. In particular, the CV and SP methods were employed to determine cost estimates using the WtPA. This was intended to achieve the second secondary objective and the third secondary objective (see section 1.3.2 for details of secondary objectives). However, the third secondary objective aimed at determining the comparability of cost estimates calculated using the HCA and the WtPA. Therefore, conclusions and recommendations in this section are more relevant in terms of this secondary objective.

Firstly, the study adjusted the cost estimates in the 2016 Cost of Crashes in South Africa report (see Labuschagne, 2016) calculated implementing the HCA using a 5.3% inflation rate for the year 2017 (Stats SA, 2018b:5). Secondly, the study further calculated cost estimates for 2017 using two different methods of the WtPA, namely the CV and SP methods. Table 6.1 compares cost estimates calculated using the three methods.

**Table 6.1: Comparison of road crash cost estimates calculated using the HCA, CVM and SPM**

| Approach | Total cost estimate | CVM ÷ HCA | SPM ÷ HCA | CVM ÷ SPM |
|---|---:|---:|---:|---:|
| HCA | 150 526 965 936 | – | – | – |
| CVM (30% risk reduction) | 718 165 128 512.30 | 4.77 | – | 4.03 |
| CVM (50% risk reduction) | 595 688 580 963.48 | 3.96 | – | 3.34 |
| SPM | 178 338 691 619.55 | – | 1.18 | – |

It is evident from Table 6.1 that cost estimates calculated using the CVM and SPM are much higher than the HCA cost estimate. The HCA cost estimate is 4.77 and 3.96 times lower than the CVM cost estimates for 30% and 50% injury risk reduction rates respectively. Furthermore, the SPM cost estimate is 1.18 times higher than the HCA estimate. This confirms conclusions of previous studies, namely that the HCA tends to undervalue the costs of road crashes and therefore lower than the WtPA cost estimates (Perovic & Tsokalis; 2008:802, 805–806). It is against this background that Perovic and Tsolakis (2008:802, 805–806) assert that the HCA is widely criticised amongst others for the inherent undervaluation of life for such groups as children and the elderly who do not contribute to economic output as much as working people. However, the WtPA is strongly applauded as the most feasible for road crash cost valuation purposes since it values the small changes in probability of injury or death that an individual could gain from a road safety intervention.

It is therefore evident that the WtPA is widely preferred over the HCA. However, both these approaches are critical depending on the purpose of cost estimates being calculated. Ismail and Abdelmageed (2010:222) recommend that, if the main concern of crash cost assessment is to inform planning to maximise the national output, then the HCA is the more appropriate of the two. However, the WtPA is more suitable when the main concern is to inform interventions intended to increase social welfare by reducing injuries and fatalities. Considering that both purposes are critical for the development of any country, it is recommended that road traffic crash cost assessment studies utilise both approaches to ensure that each crash cost assessment study conducted serves both purposes.

The study on which the research is based also found that when using the CVM, the cost estimate ranges between R595 688 580 963.48 and R718 338 691 619.30. However, the application of the SPM yields a cost estimate of R178 338 691 619.55 and the HCA of R150 526 965 936. These cost estimates imply that:

- the CV cost estimate results in a percentage GDP loss ranging between 19.1% and 23.0% and a per capita GDP[45] loss ranging between R10 539 and R12 706;
- the SP cost estimate constitutes 5.7% GDP loss and R3 155 per capita GDP loss; and
- the HCA cost estimate equals 4.8% GDP loss and R2 663 per capita GDP loss.

This further shows that motor vehicle crashes adversely affect the economy both at national and per capita levels.

### 6.2.4 Conclusions and recommendations on the structuring of the components of and relationships between the HCA and the WtPA (fourth secondary objective)

The fourth secondary objective of this study aimed at structuring the cost components of and relationships between the HCA and the WtPA. A review of international literature on good

[45] GDP per capita or per capita GDP is GDP divided by mid-year population of a country (World Bank, 2009:19).

practice in the assessment of road traffic costs was in part intended to identify approaches and methods used as well as their components. This would assist in structuring the cost components of and relationships between the HCA and the WtPA.

As indicated in section 6.2.3, cost estimates calculated using the HCA and the WtPA serve different purposes (Ismail & Abdelmageed, 2010:222). The former is suitable when cost estimates are intended for use in informing planning to maximise the national output and estimates calculated applying the latter method are used as a basis for interventions to increase social welfare by reducing injuries and fatalities. It is therefore recommended that future studies utilise both approaches to ensure that there are always up-to-date cost estimates to inform planning for both national output maximisation as well as for social welfare improvement by reducing injuries and fatalities.

The HCA forms part of the recommended hybrid framework for assessing road traffic costs in South Africa, and includes the following cost components:

- lost output, production loss, lost productivity;
- human costs, pain, grief, suffering and lost quality of life, quality adjusted life years (QALYs);
- property damage, repair costs (including costs of damage to infrastructure or roadside objects);
- administrative costs;
- medical costs;
- travel delay and vehicle operating costs, delay congestion and emissions costs, congestion costs;
- legal costs;
- emergency services, response costs;
- workplace re-occupation, recruitment and re-training costs; and
- funeral costs, premature funeral costs, accelerated funeral costs.

Previous studies (Admowicz et al., 1998:65; Hanley et al., 2001:435, 450; Mogas et al. n.d.:1) applaud the SPM over the CVM citing reasons such as the former being superior to the latter:

- in terms of the goodness of fit (pseudo-$R^2$);
- since the SPM is based on random utility theory, and SPM is a generalisation of the CVM in the sense that rather than asking people to choose between a base case and a specific alternative, the SPM asks respondents to choose between cases that are described by attributes; and

- because the SPM is consistent with consumer theory and because its focus on an attribute-based theory of value permits a superior representation of many management contexts.

It is therefore recommended that as much as the CV estimates could be computed for purposes of comparison, the SPM cost estimates should be used to inform interventions intended to improve social welfare by reducing road traffic crash injuries and fatalities.

The main objective of this study was to propose a hybrid framework for assessing the cost of road traffic crashes in South Africa (see section 1.3.1). Therefore, in order to ensure that future road crash assessment studies serve both purposes as recommended by Ismail and Abdelmageed (2010:222), this study recommends the hybrid framework depicted in Figure 6.3 as proposed by this study to be adopted.

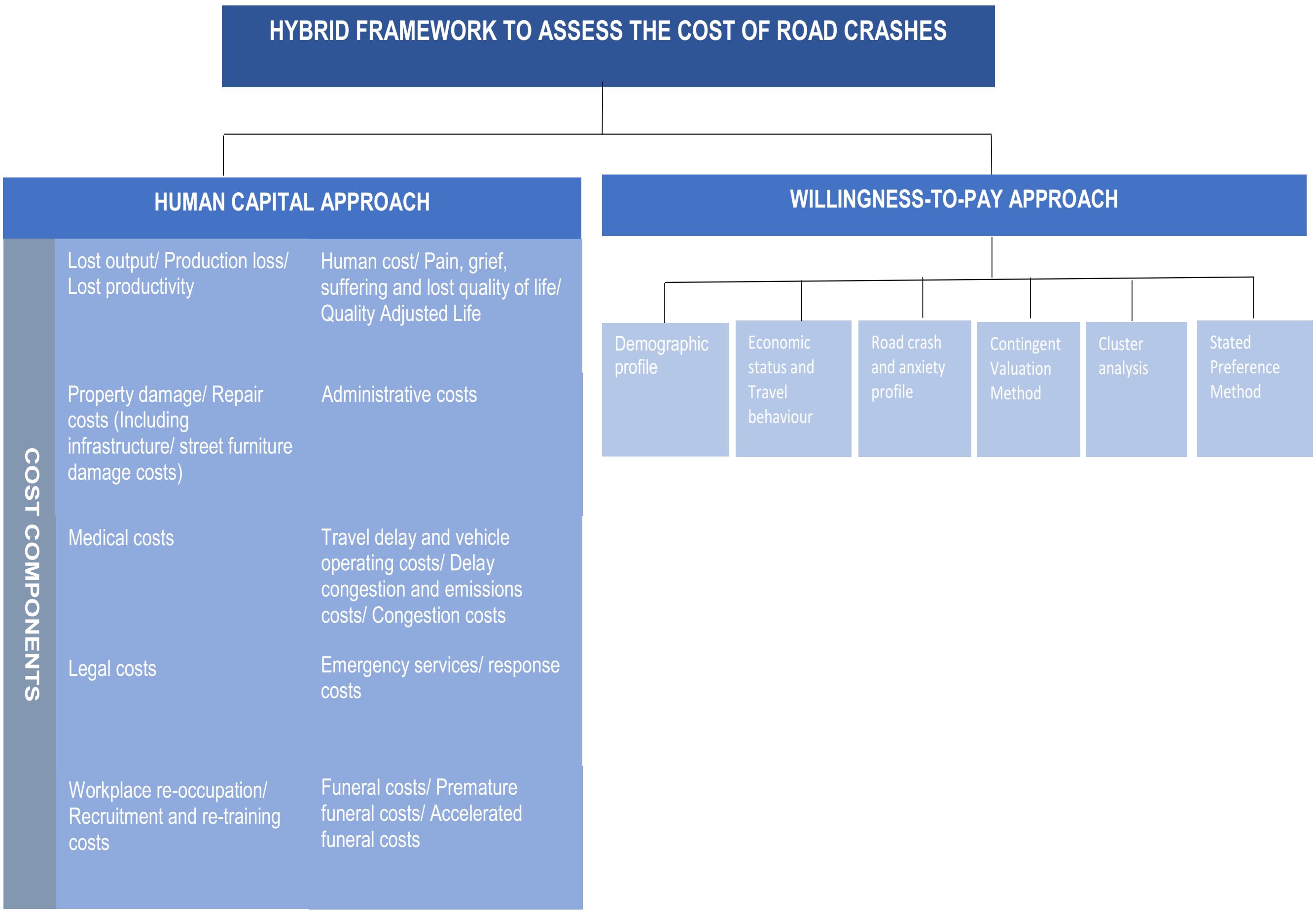


**Figure 6.2: A hybrid framework to assess the cost of road crashes in South Africa**

It is clear from Figure 6.2 that the hybrid framework advocates for the combination of the HCA and the WtPA in one road traffic crash cost assessment study.

The HCA part of the proposed hybrid framework consists of the cost components listed on the left side of Figure 6.2 and explained in detail in section 4.5.1.1. The WtPA part needs to use two methods that international literature reported to be robust, namely the CVM and the SPM. The components of the WtPA part of the proposed framework appear on the right side of Figure 6.2.

In the application of the CVM, the following data were collected on respondents:

- demographic profiles;
- economic status and travel behaviour;
- road crash and anxiety or worry profile; and
- contingent valuation of road traffic crashes.

Data on respondents' demographic profiles, economic status and travel behaviour as well as road crash and anxiety profile were used for cluster analysis to group respondents into homogeneous groups to help establish whether these clusters affect respondents' willingness to pay to reduce the risk of road traffic injury (see the right side of the hybrid framework in Figure 6.2). The CV responses were used to estimate the VoSL range, which was also used to estimate the range of the cost of road traffic crashes.

It needs to be emphasised – as reported by international literature reviewed for the purpose of this study – that the SPM is applauded as the superior method compared to the CVM. Therefore, this study further recommends that for purposes of comparison with HCA cost estimates, policy dialogue and motivation for resource allocation, cost estimates calculated using the SPM should be utilised. In this method, choice experiments modelling or logistic regression analysis is used to determine the viability of the model and calculate the VoSL, which is in turn used to estimate the cost of road traffic crashes.

The WtP section of the hybrid framework, which appears on the right of Figure 6.2, needs to make provision for the collection and analysis of both demographic and travel behaviour characteristics of respondents. In order to assign respondents to clusters on the basis of their differences in terms of their demographic characteristics and travel behaviour, cluster analysis needs to be performed; thus, assigning respondents to cluster memberships. Once the profiles of the respondents have been determined, the VoSL should be calculated using the CVM and the SPM. The VoSL should then be used to estimate the costs of motor vehicle crashes for the base year under consideration (2017) using each of the two methods.

In the case of the SPM, there is also a need to use logistic regression modelling to determine the effects target independent variables have on respondents' willingness to pay to reduce the risk of injury in motor vehicle crashes. The type of logistic regression modelling used for this purpose depends on the number of options from which respondents are required to choose. For example, in the case of this study, binary or binomial logistic regression analysis was employed because respondents were required to choose from two route options.

In section 6.3, areas that need further research are outlined.

### 6.3 RECOMMENDATIONS FOR FUTURE RESEARCH

This study had specific objectives to achieve as presented in section 1.3.2. Furthermore, the study illustrated the application of the WtPA in the assessment of the costs of road traffic crashes using a sample that is not representative of the SA population. However, the study also identified a number of questions and areas for which if answers and explanations could be scientifically determined, would enrich the body of knowledge. This observation therefore makes strong a case for more research to be done. This section provides recommendations in this regard. In particular, the following are recommendations to improve future similar road traffic crash cost assessment studies:

a. In order to achieve convergence between cost estimates calculated using the CVM and the SPM, it is recommended that in line with a recommendation by Boyle, Morrison and Taylor (2004:2), a similar study be conducted where respondents are initially given a hypothetical survey to answer, then a real survey, and then finally another hypothetical survey. The need for a study designed this way is justified by the fact that Boyle et al. (2004:2) found that empirical evidence from the study they refer to demonstrated convergence between the results of the real survey and the second hypothetical survey. This finding therefore supports a conclusion that sequencing of surveys could induce respondents to answer truthfully.
b. Since this study only used employees of the DoT and its agencies (C-BRTA, RAF, RSR, RTIA, RTMC and SANRAL) as respondents, the study needs to be replicated using a representative sample across the nine provinces of South Africa. In addition to improving the representativeness of the sample and therefore the subsequent road traffic cost estimates, this will also address the skewness of the data used as evident from the high mean values of risk reduction found in this study.
c. In keeping with Boyle et al.'s (2004:2) assertion that there is an increasing use of the SPM to generate cost estimates in such disciplines as environmental studies,

economics and transportation, a study needs to be conducted only comparing cost estimates calculated using the HCA and the SPM.

## 6.4 LIMITATIONS OF THE STUDY

This study only used employees of the DoT and its agencies (C-BRTA, RAF, RSR, RTIA, RTMC and SANRAL). Furthermore, scenarios used for both CV and SP questions were based on the Gauteng Freeway Improvement Project (GFIP) e-toll fees, travel time and fatality statistics. As a result, the WtP figures and therefore the subsequent VoSL and crash cost estimates of this study cannot be generalised as representative of the SA population. It is against this background that the second recommendation is made regarding future research, namely to replicate the same study with a sample representative of the national population across all nine provinces in SA.

Furthermore, the literature review on SA studies only focused on those that could be availed by the CSIR commissioned by the DoT. There is therefore a need for a further review of literature focusing on all road traffic cost assessment studies conducted in South Africa beyond those only provided by the CSIR for the purpose of this study.

## 6.5 CONTRIBUTION OF THE STUDY

The contribution of this study can be grouped at three levels, namely practical, theoretical and methodological. The contributions of the study are therefore discussed under each of these levels below.

### 6.5.1 Contribution of the study at practical level

In an effort to determine the applicability of the WtPA, this study investigated the WtPA, particularly using the CVM and the SPM of this approach in the SA context. This was done in order to achieve the second secondary objective of this study (i.e. to investigate the WtPA empirically in the SA context) (see section 1.3.2). It was intended to calculate the costs of road traffic crashes using these two methods of the WtPA for comparison with the HCA cost estimates as envisaged by the third secondary objective (to determine the comparability of the cost estimates of the HCA and the WtPA). Therefore, this study demonstrated that it is possible to use the WtPA to assess the costs of road traffic crashes in South Africa, particularly using the CVM and the SPM of this approach.

The study introduced the application of two-step cluster analysis to categorise respondents into groups (see section 5.2.2.5). The purpose of cluster analysis is to maximise heterogeneity between segments (Hair et al., 2010:508; Zikmund et al., 2013:597). According to Rundle-Thiele et al. (2015:526), two-step cluster analysis allows the simultaneous analysis of both categorical and continuous data, which was highly appropriate in this study where categorical and (self-reported) behavioural data were analysed at the same time. Two-step clustering identifies the groupings by running pre-clustering first and then by using hierarchical methods (Rundle-Thiele et al., 2015:526). It is against this background that two-step cluster analysis was performed to determine whether distinguishable respondent profiles exist that represent their demographic information and explain their WtP behaviour. In particular, the current study considered the following characteristics and demographic information: age, gender, education level, income level, involvement in road crash in the past, main purpose of travel, car or vehicle ownership, hours travelled per day, level of anxiety or worry of self or family member being involved in a road crash, and mode of transportation.

In order to determine model relationships between the three independent variables of interest in this study, namely cost, travel time and fatalities and willingness to pay or route choice, MNL regression analysis and binary logistic regression analysis were performed. However, the results for both the MNL model and the binary logit model were exactly the same as the experiment only involved two choices. As a result, only the results of the binary logistic regression model are presented in this section. However, this is one of the major contributions of this study from a research practice perspective.

### 6.5.2 Contribution of the study at theoretical level

This study confirmed conclusions of previous studies conducted globally that the HCA undervalues the actual cost of road traffic crashes, which is in part attributed to low values assigned to lives of children and the elderly (Tooth, 2010:4). Wren and Barrell (2010:15) also report that, in addition to underestimating the value of life of the elderly and children, the traditional HCA does not measure the intangible costs of pain and suffering or loss of quality of life. This is attributed to the fact that the HCA values life using market earnings, which are lower for these population groups because children and the elderly do not contribute to the national output due to their inactivity in the economy (Wren & Barrel, 2010:15).

### 6.5.3 Contribution of the study at methodological level

Using lessons learned from the review of international literature on good practice in the assessment of road traffic crashes, this study identified common components and relationships of the HCA and the WtPA. This enabled the structuring of components of and relationships between the HCA and the WtPA for use in SA studies; thus, achieving the fourth secondary objective of this study (i.e. to structure the components of and the relationship between the HCA and the WtPA).

Contrary to previous studies, this study found a vast difference between cost estimates calculated using the CVM and those using the SPM. In particular, CV estimates in this study were four to five times higher than the SP estimates for 50% and 30% risk reduction respectively. This finding makes a strong case for the support of Boyle et al.'s (2004:2) recommendation that in order to achieve convergence between cost estimates calculated using the CVM and the SPM, respondents should initially be given a hypothetical survey to answer, then a real survey, and then finally another hypothetical survey. This data collection approach is informed by Boyle et al.'s (2004:2) assertion that sequencing of surveys can induce respondents to answer truthfully.

Furthermore, since the early 1960s, South Africa has been using the HCA in assessing the costs of road traffic crashes. The use of this approach continued despite a shift by such road safety performance global leaders as Belgium, the Netherlands, the United Kingdom, Singapore and Sweden towards the use of the WtPA. The HCA is preferred by the Asian Development Bank (ADB) and TRL of the United Kingdom for use in developing countries (De Leon et al., 2005:3185; TRL, 1995:4). However, this justification no longer holds water in the case of South Africa, since the country has economic characteristics of both developing and developed countries (World Bank, 2011). It therefore makes sense for approaches used in the assessment of road traffic crashes to consider these peculiarities. This therefore justifies combining the HCA and the WtPA in one study. This approach to crash cost assessment is further supported by the different purposes cost estimates calculated using these two approaches serve (see sections 1.2 and 6.2.4). Furthermore, in terms of the WtPA, considering the assertion by Niroomand and Jenkins (2016:4) that from the perspective of economic theory, the CVM and SPM allow estimation of incremental marginal economic welfare benefits that improve road safety, this study also applied both methods. This study therefore adds to the existing body of knowledge by demonstrating the feasibility of using both the HCA and the WtPA in one study in the context of South Africa.

The extremely high CV cost estimates relative to both HC and SP estimates make the cost estimates calculated using the former suspect thus providing more ground to recommend the use of the SPM over CVM. This is in line with previous studies (Admowicz et al., 1998:65; Hanley et al., 2001:435, 450; Mogas et al., n.d.:1; Robinson, 1993:5; Scarpa & Willis, 2006:465) that applaud the SPM over the CVM citing the following reasons in favour of the former, namely that the SPM is:

- superior in terms of the goodness of fit (pseudo-$R^2$);
- based on random utility theory, and a generalisation of the former in the sense that rather than asking people to choose between a base case and a specific alternative,

the SPM asks respondents to choose between cases that are described by attributes;

- theoretically more sound and
- consistent with consumer theory and its focus on an attribute-based theory of value, which permits a superior representation of many management contexts.

The assertion above is supported by Bahamonde-Birke et al. (2015:488) as well as Sakashita et al. (2012:n.p.) who conclude that the WtPA appears to be the leading approach for assessing the VoSL and that:

a. the SPM represents the current state-of-the-art method for determining the willingness to pay for non-market goods; and
b. the use of the contingent valuation is no longer recommended by several researchers, such as Hausman (2012:43–44, 47), who label the method as "hopeless" due to its hypothetical response bias[46] that leads to overstatement of values as was the case in this study and that –

> The assessed value of a public good is demonstrably arbitrary, because willingness to pay for the same good can vary over a wide range depending on whether the good is assessed on its own or embedded as part of a more inclusive package."

Furthermore, due to scope[47] and scale biases, CV estimates provided by respondents could be insensitive to changing health outcomes in terms of:

- consequences (scope bias), for example minor injury versus serious injury; and
- magnitude of risk reduction (scale bias), for instance 30% versus 50% reduction, as it is the case in this study (Sakashita et al., 2012:n.p.).

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[46] 'Hypothetical bias' refers to the fact that measures of willingness to pay (WtP) from a hypothetical scenario deviate from measures of WtP in a real market scenario (Svensson, 2009:432). Furthermore, hypothetical bias is also usually regarded as deviating positively from a real market situation, i.e. it is an excess of 'yes' votes in a hypothetical referendum or purchase scenario compared to a real market situation (Svensson, 2009:6). Hausman (2012:44) defines hypothetical bias in CV questions as the bias that arises in answering a hypothetical question where the respondent has no market experience, i.e. what respondents provide as a response is different from what they do.

[47] 'Scope bias' refers to the fact that respondents in surveys do not reflect any sensitivity in stated WtP to how many different goods are being valued (Svensson, 2009:433). The most fundamental challenge to the CVM, and the strongest proof that the answers to such surveys are invented in response to the questions, comes from concerns that are referred to as "scope" and "embedding" (Hausman, 2012:47). This means that "the assessed value of a public good is demonstrably arbitrary, because willingness to pay for the same good can vary over a wide range depending on whether the good is assessed on its own or embedded as part of a more inclusive package (Hausman, 2012:47). For example, Diamond and Hausman (1994) cite an example of the embedding effect, where willingness to pay to clean one lake is approximately equal to stated willingness to pay to clean up five lakes, including one asked about individually (Hausman, 2012:47).

Yusoff et al. (2013:7) confirm support for the SPM by asserting that the technique is considered the most appropriate method to value road safety because of its robustness and the ability to cope with assessment on improvement or subject with no prior records and data on such situations.

The final conclusion of the study follows.

## 6.6 CONCLUSION

A road traffic crash is an event that produces injury (fatal, serious or minor) and/or property damage. It involves a vehicle in transport, and occurs on a public road or while the vehicle is still in motion after running off the public road (Bhalla et al, 2009:239; BITRE, 2009:1; Kudryavtsev et al., 2013:350; Lehohla, 2009:2; Risbey et al., 2010:1). Road traffic crash cost assessment entails the valuation of the costs imposed by road traffic crashes on society, and the cost estimate so determined is used by planners as an important indicator for allocating resources to road safety based on cost-effectiveness and cost–benefit analyses (Bhalla, 2013:8; Bliss & Breen, 2009:11; Wijnen & Stipdonk, 2016:97). The primary objective of this study was to develop a hybrid framework for use in assessing the cost of road traffic crashes in South Africa (see section 1.3.1). This primary objective was achieved by realising four secondary objectives (stated first in section 1.3.2), namely to:

- provide a literature review on international best practice in the assessment of the cost of road traffic crashes;
- investigate the WtPA empirically in the SA context;
- determine the comparability of the cost estimates of the HCA and the WtPA; and
- structure the components of and the relationship between the HCA and the WtPA.

It is evident from sections 6.2.1 to 6.2.4 that the study achieved the secondary objectives and therefore the primary objective. In order to demonstrate that the primary objective has been achieved, the hybrid framework to assess the costs of road traffic crashes in South Africa that this study set out to develop and propose was presented in Figure 6.3.

Studies of this nature are critical for any country because road traffic crashes are not just a transport challenge; they are also a social and economic problem. The road safety challenge is increasing exponentially against the backdrop of dwindling resources. As a result, there is a need for a sound economic basis to engage in a planning dialogue based on sound economic principles to justify allocation of investment resources in proportion to the magnitude of the challenge at hand. This study therefore aimed to contribute towards a more rigorous and internationally comparable approach for assessing the cost of road crashes in South Africa. In terms of this contribution, the study developed and proposes a hybrid framework for assessing the cost of motor vehicle crashes in the country. The framework combines two valuation approaches for application to assess the cost of road traffic crashes in one study, namely the HCA and the WtPA.

Further value added by this study is the use of cluster analysis to categorise respondents by their demographic characteristics into groups or clusters. Another contribution of the study is the finding through the analysis of the two clusters that having been involved in a motor vehicle crash of any type and whether respondents had sustained any injury as a result of a motor vehicle crash were variables found to contribute most towards respondents' willingness to pay to reduce their risk of injury in road crashes. This finding confirms previous research by Haddak (2016:301) that while the level of severity of injury had no influence on the likelihood of the contribution of individuals, it has an influence on the amount of contributions or willingness to pay to reduce the risk of injury in motor vehicle crashes. The current study further found that the cluster consisting mainly of males who had been involved in a road traffic crash in the past but did not sustain any injuries indicated, on average, a higher willingness to pay an extra amount than the females who had never been involved in a motor vehicle crash.

To date, limited research had been conducted in South Africa combining and comparing road crash cost estimates of the HCA and the WtPA. This is despite Ismail and Abdelmageed (2010:222) recommending that if the main concern of a road crash cost assessment study is to inform planning to maximise the national output then the HCA is the appropriate methodology to use. However, the WtPA is the more suitable method when the main concern is to inform interventions intended to increase social welfare by reducing injuries and fatalities (Ismail & Abdelmageed, 2010:222). This study attempt was a first of its kind in the SA context using these two approaches in one study. In line with Ismail and Abdelmageed (2010:222), adoption of this approach for assessing the cost of road crashes will serve the two purposes of informing planning to maximise the national output as well as informing interventions intended to increase social welfare.

The application of binary or binomial logistic regression analysis in testing the significance and explanatory power of a model that considers the independent variables used for the SPM, namely cost, time and fatalities was performed. These are variables that are included in the regression model to explain respondents' route choices and therefore willingness to pay. The study particularly found through the application of the binary logistic regression analysis that:

- the 'cost' variable correlates positively to route choice and improve the model, and the variable also contributes significantly to the model ($p = .00 < .01$). The study revealed that cost is 1.252 times more likely to predict route choice and therefore willingness to pay for reduced risk of injury.

- the 'time' and 'fatalities' variables correlate negatively with route choice and therefore willingness to pay, and they contribute significantly to the model (for both variables, $p = .00 < .01$). They are respectively .950 and .901 less likely to predict route choice and therefore willingness to pay for a reduction in the risk of injury in motor vehicle crashes; and
- the 'constant' alone does not significantly contribute to the model since $p = .370 > .05$.

To demonstrate the significance and strength of the model and therefore its viability further, the study also established that in 96.0% of the time that predictions are made based on the model, the predictions will be correct.

Studies conducted globally concluded that the HCA is criticised for not necessarily supporting an efficient allocation of scarce resources to road safety and infrastructure (BITRE, 2009:3; Perovic & Tsolakis; 2008:802, 805–806). Furthermore, the approach is also criticised for undervaluing the cost of road traffic crashes due to understating human costs, particularly those for the elderly and children who do not contribute relatively as much to economic output as working people (BITRE, 2009:3; Perovic & Tsolakis; 2008:802, 805–806). On the other hand, the WtPA is strongly applauded as the most feasible approach for road crash cost valuation since it values the small changes in probability of injury or death that an individual could gain from a road safety intervention (BITRE, 2009:3; Perovic & Tsolakis; 2008:802, 805–806). The findings of this study also confirm these assertions as it found motor vehicle cost estimates calculated using the two WtPA methods (i.e. CVM and SPM) to be much higher than the HCA cost estimate. In particular, this study found the CV cost estimate to be between 3.96 and 4.77 times more than the cost estimate calculated using the HCA. Furthermore, the SP cost estimate was 1.18 times higher than the cost estimate calculated using the HCA. Again, cost estimates calculated using the HCA, CVM and SPM respectively translated to:

- 4.8% GDP loss and R2 663 per capita GDP loss;
- percentage GDP loss ranging between 19.1% and 23.0% and the cost estimate equalling a per capita GDP loss ranging between R10 539 and R12 706; and
- 5.7% GDP loss and R3 155.21 per capita GDP loss.

Therefore, replication of this study on a nationally representative scale will go a long way in providing road traffic crash cost estimates that could be used as inputs into CBA to inform resource allocation for road safety interventions. These interventions would reduce road traffic crashes and resulting injuries and property damage; thus, addressing the social, economic and health challenges South Africa faces as a result of road traffic crashes.

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# Appendices

## Appendix A: Participant information sheet

23 June 2017

**Title: A hybrid framework for assessing the cost of road crashes in South Africa**

**Dear Prospective Respondent**

My name is Hlengani Moyana and I am doing research with Prof. Cine van Zyl, a Professor, in the Department of Entrepreneuership, Supply Chain, Transport, Tourism and Logistics Management towards a Doctor of Philosophy degree in Transport Economics at the University of South Africa. I am inviting you to participate in a study entitled **A hybrid framework for assessing the cost of road crashes in South Africa**.

The aim of this study is to propose an alternative to the approach currently used in South Africa to assess the cost of road traffic crashes. I am therefore conducting this research to find out about best practices for assessing the cost of road crashes globally with a view to adapt approaches used by countries that are world leaders in road safety performance and costing of road crashes.

You are one of the employees of the National Department of Transport or Road Traffic Management Corporation or Railway Safety Regulator or Cross-Boarder Road Transport Agency or Road Accident Fund or Road Traffic Infringement Agency or South African National Roads Agency Limited at supervisory or management level chosen to participate in this study because as a member of the public who uses road transport on a daily basis for one reason or another thus facing a risk of injury due to accidents, you stand to benefit from investment in road safety programmes. After the Director-General of the Department of Transport or the Chief Executive Officer granted us permission for the employees of the Department to participate in this study, we requested for email addresses of all employees at supervisory and management levels so that we could randomly select those of you that need to participate in the survey so that we can forward the link to the online questionnaire that all selected participants are requested to complete. You were therefore purposefully chosen to participate in this study because you are working for the Department or Agency occupying either supervisory or management level. At least 100 employees of the Department and Agencies including yourself have been selected to participate in this survey.

The study involves a survey questionnaire which participants are requested to complete. It will take you about 30 minutes to complete the questionnaire online. The questionnaire consists of three sections. The first section requires you to provide information about your age, gender, marital status, whether you have children or not, monthly income range, car ownership, whether you or your relatives/ family members were ever involved in a car accident in the past and also indicate the severity of your or their injury and also to indicate whether you are concerned about your or your family members' or relatives' risk of getting injured or killed in a car accident. The second section of the questionnaire requires you to indicate how much you are willing to pay to reduce your or your relatives' or family members' risk of injury in car accident. The third section provides two scenarios of route options which differ in terms of travel time, cost of travel, and number of fatalities per annum. You are required to consider differences in these routes in terms of the three dimensions and indicate which of the two you would choose for your journey. This is another way of establishing your willingness to pay to reduce your risk of injury as you travel on the road. All the questions in the questionnaire are multiple choice questions.

Being in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be required to indicate online whether or not you agree to participate in the study and this will serve as your written consent to participate in the survey. However, the fact that you will be completing the questionnaire anonymously without providing personal information to enable the researcher or any other person to identify you, it will not be possible for your completed questionnaire to be withdrawn from the study once you have completed and submitted it.

By participating in this study, you will be contributing towards a study intended to assess the cost of road crashes which are used for cost-benefit analysis to inform resource allocation/ investment in road safety programmes intended to reduce the number of people injured and killed on our roads. Reduction in the number of people injured and killed on our roads results in reduction in road trauma for the South African society and frees financial resources that should be used to implement road trauma related interventions for use in job creating and economy growing government programmes.

There will be no inconvenience for you that will result from taking part in this study since you will complete the questionnaire anonymously. Furthermore, it will only take 30 minutes of your time to complete the questionnaire. Your name will not be recorded anywhere in the questionnaire and no one will be able to connect you to the answers you give. Only the researcher and the Statistician who will assist in analyzing the data will have access to the information that you will provide and both of them will not be able to identify you through the questionnaire since you will not be required to provide identifying information in the questionnaire. Your answers may be reviewed by the UNISA Research Ethics Committee to make sure that research is done properly. However, it will not be possible for the Committee members to identify you since you are not required to provide information that will identify you. Apart from the research report for which the data is being collected, the anonymous data that participants will provide may also be used in preparation of journal articles and conference presentations as well. The research report may be submitted for publication, however individual participants will not be identifiable in the report. Your electronic answers will be stored in a password-protected computer by the researcher for a period of five years; after which period the data will be permanently deleted from any electronic device owned by the researcher. You will not receive payment or any incentives for participating in this study.

This study has received written approval from the Research Ethics Committee of the College of Economic and Management Sciences, UNISA. A copy of the approval letter can be obtained from the researcher on request. If you would like to be informed of the final research findings, please contact Dr Hlengani Moyana on 082 8557559 or HlenganiJM@rtmc.co.za or hmoyana45@gmail.com. Should you require any further information or want to contact the researcher about any aspect of this study, please contact Dr Hlengani Moyana on the above-mentioned contact details. Should you have concerns about the way in which the research has been conducted, you may contact Professor Cine van Zyl on 082 668 1968 or VZylc@unisa.ac.za.

Thank you for taking time to read this information sheet and for participating in this study.

Thank you.

**Dr Hlengani Moyana (Researcher)**

## Appendix B: Consent to participate in the research study

- I confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.
- I have read and understood the study as explained in the information sheet.
- I have had sufficient opportunity to ask questions and am prepared to participate in the study.
- I understand that my participation is voluntary, and that I am free to withdraw at any time without penalty (if applicable).
- I am aware that the findings of this study will be anonymously processed into a research report, journal publications and/or conference proceedings.
- I have received a signed copy of the informed consent agreement

**I understand and accept the above.**

Please choose only one of the following:

| | |
|---|---|
| Yes | |
| No | |

## Appendix C: Willingness-to-pay to reduce the risk of road traffic crash injury or death survey questionnaire

## COVER LETTER

**WILLINGNESS-TO-PAY TO REDUCE THE 'RISK OF ROAD TRAFFIC CRASH INJURY OR DEATH SURVEY' QUESTIONNAIRE**

**A HYBRID FRAMEWORK FOR ASSESSING THE COST OF ROAD CRASHES IN SOUTH AFRICA**

Dear Prospective Participant

You are invited to participate in a survey conducted by Hlengani J. Moyana towards the qualification of a Doctor of Philosophy degree in Transport Economics under the supervision of Cine van Zyl, Professor in the Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management at the University of South Africa (UNISA).

The questionnaire you have received has been designed to collect data for use in proposing an alternative to the approach currently being used in South Africa to assess the cost of road traffic accidents. You have been selected to participate in this survey as you form part of the supervisory or management or senior/executive management team at one of the following organisations:

- Railway Safety Regulator;
- Cross-Border Road Transport Agency;
- Road Accident Fund;
- Road Traffic Infringement Agency;
- Road Traffic Management Corporation; or
- the South African National Roads Agency Limited (SANRAL).

These organisations are some of the agencies of the Department of Transport. You are also a member of the public who uses road transport on a daily basis for one reason or another. Therefore, you are facing a daily risk of injury due to accidents. You stand to benefit from investment in road safety programmes.

By completing this questionnaire, you agree that the information you provide may be used for research purposes, including dissemination through peer-reviewed publications and conference proceedings. It is anticipated that the information we gain from this questionnaire will help the researcher to understand the South African society's willingness to pay to reduce the risk of injury in motor vehicle accidents better. You are, however, under no obligation to complete the questionnaire and you may withdraw from the research study prior to submitting the questionnaire. The questionnaire is developed to be anonymous. This means that we will have no way to connect the information that you provide to you personally.

If you choose to participate in this survey, it will take no more than 15 minutes of your time. You will not benefit from your participation as an individual. However, it is envisioned that the findings of this research study will contribute towards the body of knowledge to calculate motor vehicle accidents costs and the costing approaches.

The records will be kept for five years for audit purposes after which it will be permanently destroyed. Hard copies will be shredded and electronic versions will be permanently deleted from the hard drive of the device on which the information is stored. You will not be reimbursed or receive any incentives for your participation in the survey.

The research was reviewed and approved by the Unisa Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management Ethics Review Committee. The primary researcher, Hlengani J Moyana, can be contacted during office hours at 082 855 7559 or on email at hmoyana45@gmail.com. The study leader, Professor C van Zyl can be contacted during office hours at 082 668 1968 or on email at VZylc@unisa.ac.za.

You are making a decision whether or not to participate by continuing to the next page.

Should you have concerns about the way in which the research has been conducted, you may contact Professor Cine van Zyl at 082 668 1968 or on email at VZylc@unisa.ac.za.

Thank you for taking time to read this information sheet and for participating in this study.

**Hlengani J Moyana (Researcher)**

**SECTION A – GENERAL INFORMATION**

## 1 Respondent's profile

### 1.1 **Position at work** (Please tick the applicable response)**:**

| Senior Admin Clerk | Assistant Director | Deputy Director | Director/ Senior Manager | Chief Director/ Executive Manager | Deputy Director-General/ Senior Executive Manager/ Chief Operations Officer | Director-General/ Chief Executive Officer | Other (specify) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

### 1.2 **Gender:**

What is your gender? (Please tick the applicable response.)

| Female | Male |
|---|---|
| | |

### 1.3 **Age:**

How old are you? (Please tick the applicable age category in years.)

| 18–24 | 25–34 | 35–44 | 45–54 | 55–64 |
|---|---|---|---|---|
| | | | | |

### 1.4 **Education:**

What are your educational qualification(s)? (Please tick the applicable response.)

| Below Grade 12 | Grade 12 National Certificate | Diploma | Higher Certificate | Degree | Master's degree | Doctoral degree |
|---|---|---|---|---|---|---|
| | | | | | | |

1.5 **Car or vehicle ownership:**

Number of cars or vehicles that I own (Please tick the applicable box.)

| No car or vehicle | One car or vehicle | More than one car or vehicle |
|---|---|---|
| | | |

1.6 **Income*:***

What is your gross monthly income in rand?

| 10 000–20 000 | 20 001–30 000 | 30 001–40 000 | 40 001–50 000 | 50 001–60 000 | 60 001–70 000 | 70 001–80 000 | More than 80 000 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

The next section deals with questions regarding car or vehicle accidents with regard to previous experiences of your/family members/close relatives with regard to motor vehicle accidents.

1.7 **Motor vehicle accident:**

Were you involved in a motor vehicle accident of any type in the past? (Please tick the applicable response.)

| Yes | No |
|---|---|
| | |

Did you have any injuries as a result of the motor vehicle accident?

| Yes | No |
|---|---|
| | |

If your response is "Yes", what was your degree of injury in your opinion? (Please tick the applicable box.)

| | | |
|---|---|---|
| Minor injuries | Serious injuries | Not applicable |

1.8 **Relative or close family injury:**

Was a relative or a close family member injured during the last 12 months in a road traffic crash/accident? (Please tick the applicable box.)

| | |
|---|---|
| Yes | No |

If your response is “Yes”, what was the degree of injury? (Please tick the applicable box.)

| | | | |
|---|---|---|---|
| Minor injuries | Serious injuries | Death | Not applicable |

1.9 **Hours travelled per day:**

How much time do you spend travelling on the road per day?

| | | | | | |
|---|---|---|---|---|---|
| 0–30 minutes | 1–2 hours | 3–4 hours | 5–6 hours | 7–8 hours | 9 hours and more |

1.10 **Level of anxiety:**

Rate your level of anxiety/worry about the risk of getting involved in a road accident involving yourself and/or close family (Please tick the applicable box.)

| | | | |
|---|---|---|---|
| Not worried at all | A bit worried | Moderately worried | Extremely worried |

1.11 **Mobility on a weekday:**

My main purpose of travel is:

| | |
|---|---|
| Compelling reasons (work, studies, hospital/clinic, …) | Non-compelling reasons (shopping, spare time, visits, …) |

1.12 **Mode of transportation**:

Which mode of transport do you use the most? (Please tick the applicable box.)

| | | | |
|---|---|---|---|
| Private car/vehicle | Public transport | Bike/ Motorised two-wheeler | Walking |

**SECTION B – ROAD ACCIDENT CONTINGENT VALUATION**

## 2 Road Accident Contingent Valuation

**The next section is designed to learn about what you think about risks when travelling on the road, and how much you value your safety when travelling.**

2.1 Imagine that you have decided to walk to a friend's house. There are two different possible routes, both which involve crossing busy roads.

Which one of the following roads is safer to cross? (Please tick the applicable box.)

| | |
|---|---|
| Crossing Road A has a risk of 20 in 100 000 that you will be injured in a accident. | |
| Crossing Road B has a risk of 40 in 100 000 that you will be injured in a accident. | |

2.2 Now imagine that you have to make a journey every weekday of the year for some reason.

2.2.1 Suppose the government has a programme to improve the safety of your daily journey, which would reduce the annual risk of being injured to 170 people per million population. That is, there would be approximately 30% reduction in the risk of being injured.

How much are you willing to pay per day for the reduction in this risk (in South African rand)? The costs shown are for a one-way journey only. (Please tick the applicable option.)

| Per day | 7.40 | 14.79 | 22.19 | 29.59 | 36.99 | 44.38 | 51.78 | 59.18 | 66.58 | More than 66.58 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

2.2.2 Suppose the government has a programme to improve the safety of your daily journey that would reduce the annual risk of being injured to 115 people per million population. That is, there would be approximately 50% reduction in the risk of being injured.

How much are you willing to pay daily for the reduction in this risk (in South African rand)? The costs shown are for a one-way journey only. (Please tick the applicable option.)

| Per day | 7.40 | 14.79 | 22.19 | 29.59 | 36.99 | 44.38 | 51.78 | 59.18 | 66.58 | More than 66.58 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

## 3 Stated preference (SP) questions – Choice game

We would now like you to think about your journey again and imagine a situation where you had the choice between two different imaginary routes.

The times and costs shown are for a one-way journey only.

Each option is described in terms of:

- Electronic Road Pricing (ERP)/Toll Charges (in cents). These are the toll charges you would have to pay.
- Journey time (in busy traffic conditions)

  *You can travel pretty much at the speed limit but you are forced to change lanes every now and then.*
- The number of people who are fatally injured (killed) on the route over an average year.

<u>Current statistics</u>

The current number of fatalities per year estimated from the accident records for your route is estimated as being 3.

| | **ROUTE A** | **ROUTE B** |
|---|---|---|
| Cost (in cents) | 325 | 200 |
| Travel time under busy conditions | 20 | 28 |
| Number of fatalities annually | 3 | 2 |

Given this choice, I would choose: (Please tick the applicable option.)

| Route A | Route B |
|---|---|
| | |

Thank you for your valuable time to complete the questionnaire.

## Appendix D: Follow-up willingness-to-pay to reduce the risk of road traffic crash injury questionnaire

### COVER LETTER - A HYBRID FRAMEWORK FOR ASSESSING THE COST OF ROAD CRASHES IN SOUTH AFRICA

Dear Prospective participant,

You are invited to participate in a follow-up survey conducted by Hlengani Moyana towards a Doctor of Philosophy degree in Transport Economics under the supervision of Cine van Zyl, a Professor in the Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management at the University of South Africa.

The questionnaire you have received has been designed to collect data for use in proposing an alternative to the approach currently used in South Africa to assess the cost of road traffic crashes. You were selected to participate in this survey because you form part of the supervisory or management or senior/executive management team at the Railway Safety Regulator or Cross-Boarder Road Transport Agency or Road Accident Fund or Road Traffic Infringement Agency or Road Traffic Management Corporation or the South African National Roads Agency Limited, which are some of the Agencies of the Department of Transport, and as a member of the public who uses road transport on a daily basis for one reason or another thus facing a risk of injury due to accidents, you stand to benefit from investment in road safety programmes.

By completing this questionnaire, you agree that the information you provide may be used for research purposes, including dissemination through peer-reviewed publications and conference proceedings. It is anticipated that the information we gain from this questionnaire will help us to better understand the South African society's willingness to pay to reduce the risk of injury in motor vehicle accidents.

You are, however, under no obligation to complete the questionnaire and you can withdraw from the study prior to submitting the questionnaire. The questionnaire is developed to be anonymous, meaning that we will have no way of connecting the information that you provide to you personally.

If you choose to participate in this survey it will take no more than 10 minutes of your time. You will not benefit from your participation as an individual, however, it is envisioned that the findings of this study will contribute towards the body of knowledge of motor vehicle accidents costing approaches.

We foresee the following consequences in completing the survey: We need 10 minutes of your time to participate in the survey. The researcher undertakes to keep any information provided herein confidential, not to let it out of our possession and to report on the findings from the perspective of the participating group and not from the perspective of an individual.

The records will be kept for five years for audit purposes where after it will be permanently destroyed. Hard copies will be shredded and electronic versions will be permanently deleted from the hard drive of the device the information is stored on. You will not be reimbursed or receive any incentives for your participation in the survey.

The research was reviewed and approved by the UNISA Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management Ethics Review Committee. The primary researcher, Hlengani Moyana, can be contacted during office hours at 082 855 7559 or hmoyana45@gmail.com. The study leader, Professor Cine van Zyl can be contacted during office hours at 082 668 1968 or email at VZylc@unisa.ac.za.

You are making a decision whether or not to participate by continuing to the next page. You are free to withdraw from the study at any time prior to submitting your completed questionnaire.

Should you have concerns about the way in which the research has been conducted, you may contact Professor Cine van Zyl on 082 668 1968 or email at VZylc@unisa.ac.za.

Thank you for taking time to read this information sheet and for participating in this study.

**SECTION A – GENERAL INFORMATION**

**2 Respondent's profile**

1.1 **Position at work:**

| Senior Admin Clerk | Assistant Director | Deputy Director | Director/ Senior Manager | Chief Director/ Executive Manager | Deputy Director-General/ Senior Executive Manager/ Chief Operations Officer | Director-General/ Chief Executive Officer | Other (specify) |
|---|---|---|---|---|---|---|---|

1.2 **Gender:**

What is your sex/ gender? (Tick the applicable response)

| Female | Male |
|---|---|

1.3 **Age:**

How old are you? (Tick the applicable age category)

| 18-24 | 25-34 | 35-44 | 45-54 | 55-64 |
|---|---|---|---|---|

1.4 **Education:**

What is your highest educational qualification? (Tick the applicable response)

| Below Grade 12 | Grade 12 National Certificate | Diploma | Higher Certificate | Degree | Post-graduate |
|---|---|---|---|---|---|
| | | | | | |

1.5 **Car ownership:**

Number of cars or vehicles I own (Tick the applicable box)

| No car | One car | More than one car |
|---|---|---|
| | | |

1.6 **Income***:*

What is your gross monthly income in Rands?

| Below 10,000 | 10,000 - 20,000 | 20,001 - 30,000 | 30,001 - 40,000 | 40,001 - 50,000 | 50,001 - 60,000 | 60,001 - 70,000 | 70,001 - 80,000 | Over 80,000 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

The following section deals with questions regarding car accidents with regard to your previous experiences with motor vehicle accidents. All information will be kept confidential and you can withdraw at any stage.

1.7 **Motor Vehicle Accident:**

Were you involved in a motor vehicle accident of any type in the past? (Tick the applicable response)

| Yes | No |
|---|---|
| | |

Did you sustain any injuries as a result of the motor vehicle accident? (Tick the applicable response)

| Yes | No |
|---|---|
| | |

If your response is “Yes”, what was your degree of injury in your opinion? (Tick the applicable box)

| Minor injuries | Serious injuries | Not applicable |
|---|---|---|
| | | |

SECTION B – ROAD CRASH/ ACCIDENT CONTINGENT VALUATION

## 2 Road Crash/ Accident Contingent Valuation

**The next section is designed to learn about what you think about risks when travelling on the road.**

2.1 Imagine that you have decided to walk to a friend's house. There are two different possible routes, both of which involve crossing busy roads.

Which of the following roads is safer to cross? (Tick the applicable box)

| | |
|---|---|
| Crossing Road A has a risk of 20 in 100,000 that you will be injured in a crash/ accident. | |
| Crossing Road B has a risk of 40 in 100,000 that you will be injured in a crash / accident. | |

## 3 Stated Preference (SP) questions – Choice Game

We would now like you to think about a journey you undertook by car/ vehicle and imagine a situation where you had the choice between two different imaginary routes.

The times and costs shown are for one-way journey only.

Each option is described in terms of:

- Toll Charges (In Rands) – This is the toll charges you would have to pay

- Journey time (in busy traffic conditions)

  *You can travel pretty much at the speed limit but you are forced to change lanes every now and then.*

- The number of people who are fatally injured (killed) on the route over an average year.

3.1

| | ROUTE A | ROUTE B |
|---|---|---|
| Cost (in Rands) | 19 | 28 |
| Travel Time in Busy Conditions (in Minutes) | 20 | 45 |
| Number of Fatalities per Year | 42 | 27 |

Given this choice I would choose: (Tick the applicable option)

| | |
|---|---|
| Route A | Route B |

3.2

| | ROUTE A | ROUTE B |
|---|---|---|
| Cost (in Rands) | 28 | 39 |
| Travel Time in Busy Conditions (in Minutes) | 60 | 20 |
| Number of Fatalities per Year | 42 | 27 |

Given this choice I would choose: (Tick the applicable option)

| | |
|---|---|
| Route A | Route B |

3.3

| | ROUTE A | ROUTE B |
|---|---|---|
| Cost (in Rands) | 19 | 28 |
| Travel Time in Busy Conditions (in Minutes) | 45 | 20 |
| Number of Fatalities per Year | 27 | 42 |

Given this choice I would choose: (Tick the applicable option)

| | |
|---|---|
| Route A | Route B |

3.4

| | ROUTE A | ROUTE B |
|---|---|---|
| Cost (in Rands) | 28 | 39 |
| Travel Time in Busy Conditions (in Minutes) | 60 | 45 |
| Number of Fatalities per Year | 27 | 21 |

Given this choice I would choose: (Tick the applicable option)

| | |
|---|---|
| Route A | Route B |

3.5

| | ROUTE A | ROUTE B |
|---|---|---|
| Cost (in Rands) | 19 | 39 |
| Travel Time in Busy Conditions (in Minutes) | 60 | 60 |
| Number of Fatalities per Year | 27 | 42 |

Given this choice I would choose: (Tick the applicable option)

| | |
|---|---|
| Route A | Route B |

3.6

| | ROUTE A | ROUTE B |
|---|---|---|
| Cost (in Rands) | 19 | 28 |
| Travel Time in Busy Conditions (in Minutes) | 20 | 45 |
| Number of Fatalities per Year | 42 | 27 |

Given this choice I would choose: (Tick the applicable option)

| | |
|---|---|
| Route A | Route B |

3.7

| | ROUTE A | ROUTE B |
|---|---|---|
| Cost (in Rands) | 28 | 39 |
| Travel Time in Busy Conditions (in Minutes) | 60 | 60 |
| Number of Fatalities per Year | 27 | 42 |

Given this choice I would choose: (Tick the applicable option)

| | |
|---|---|
| Route A | Route B |

3.8

| | ROUTE A | ROUTE B |
|---|---|---|
| Cost (in Rands) | 19 | 28 |
| Travel Time in Busy Conditions (in Minutes) | 45 | 45 |
| Number of Fatalities per Year | 42 | 27 |

Given this choice I would choose: (Tick the applicable option)

| | |
|---|---|
| Route A | Route B |

3.9

| | ROUTE A | ROUTE B |
|---|---|---|
| Cost (in Rands) | 39 | 28 |
| Travel Time in Busy Conditions (in Minutes) | 20 | 45 |
| Number of Fatalities per Year | 27 | 21 |

Given this choice I would choose: (Tick the applicable option)

| | |
|---|---|
| Route A | Route B |

Thank you for your valuable time to complete the questionnaire.

**Appendix E: Confidentiality agreement for the statistician**

**CONFIDENTIALITY AGREEMENT**

I, ____________________________________________________ the undersigned

of agree to assist the Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management in providing statistical analysis services to Dr HJ Moyana as part of his research process towards a PhD degree in Management Studies specialising in Transport Economics.

I will, in the course of my duties as aforementioned, come into possession of certain confidential information.

This will certify that, in the analysis of all road crash data that will be provided to Dr Moyana:

In so far as there is a moral case for doing so, I will treat all information contained in the dataset in the strictest of confidence and will not reveal that information to any third party (with the exception of the student's supervisor and members of the Ethics Clearance Committee if and as required) without prior written consent of the student.

In so far as there is a moral case for not doing so, I will not use the information contained in those datasets for any reason other than for the purpose of statistical analysis with a view to assisting the student in completing his thesis.

In so far as reasonable, I will store all datasets relating to the work of the student's studies securely that it does not become available to unauthorised individuals.

THIS DONE AND SIGNED AT

__________________________________________________

on this ________________________ day of __________________________ 201_

_____________________________________________

SIGNATURE

**DR M POHL**

## Appendix F: Requests for permission to conduct research

### F1 Request for permission to conduct research at the Department of Transport

**A hybrid framework for assessing the cost of road crashes in South Africa**

23 June 2017

Mr Mathabatha Mokonyama

Department of Transport

Acting Director-General

159 Struben Street

Pretoria Central

Pretoria

0002

Tel.: (012) 309 3172

Email: DirectorGeneral@dot.gov.za

Dear Mr Mokonyama,

I, Hlengani Moyana, a Divisional Head: Training and Development at the Road Traffic Management Corporation, am doing research with Professor Cine van Zyl, a Professor in the Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management towards a Doctor of Philosophy degree specialising in Transport Economics at the University of South Africa. We have funding from the University of South Africa for all study-related expenses such as fieldwork, statistical analysis technical advice and professional binding of the report for both examination and publication. We are inviting you to allow employees of the Department to participate in a study entitled **A hybrid framework for assessing the cost of road crashes in South Africa.**

The aim of the study is to:

- Review the most recent literature on international practices in the assessment of the cost of road traffic crashes;
- Update and compare the cost estimates of road traffic crashes in South Africa using the Hybrid Human Capital (considering 2016 as base year) and the Willingness-to-Pay approaches; and
- Recommend the most suitable approach aligned to international good practice for use in assessing the cost of road traffic crashes in South Africa.

The Department of Transport has been selected to participate in the study because you are directly responsible for coming up with legislation, policy and programmes to improve the state of road safety in South Africa. Furthermore, all the employees in the Department and their family members or relatives use road transport to travel for such purposes as work, education, leisure and hospital; amongst others. As a result, their participation in this study will assist in estimating the costs of road crashes that are amongst others used for cost-benefit-analysis of road safety investment options which is in line with the mandate of the Department.

The study will entail selected employees completing a Willingness-to-Pay survey questionnaire online. Only employees at supervisory and management levels will be required to complete the online survey questionnaire because they will be able to provide meaningful and appropriate answers to the contingent valuation and stated preference questions given their in-depth understanding and knowledge of the transport industry.

The benefits of this study are multi-fold in that consideration of the findings of this study will amongst others result in South African:

- Policy debates, road safety programmes impact analysis and resource allocation decisions that are based on up-to-date crash cost estimates;
- Road crash estimates that are comparable to those countries that have proven to be global leaders in road safety performance since estimates that will emanate from the current study will be calculated using methods that these countries use;
- Determination of the ratio of road crash estimates to the Gross Domestic Product (GDP) as well as
- Recommendations on how future crash cost estimates assessment could be improved.

There are no potential risks for employees participating in this study since the questionnaire that they will complete will not require them to provide personal information that will identify them.

Feedback procedure will entail submission of a summary of key findings of the study to the office of the Director-General on request. A copy of the complete research report could also be made available if necessary.

Yours sincerely,

**Dr Hlengani J. Moyana**

**RESEARCHER**

## F2 Request for permission to conduct research at the Road Traffic Management Corporation

**A hybrid framework for assessing the cost of road crashes in South Africa**

19 June 2017

Advocate Makhosini Msibi

Chief Executive Officer

Road Traffic Management Corporation

Private Bag X147

Pretoria

0001

Tel.: (012) 999 5200

Email: ZodwaM@rtmc.co.za

Dear Advocate Msibi,

I, Hlengani Moyana, a Divisional Head: Training and Development at the Road Traffic Management Corporation, am doing research with Professor Cine van Zyl, a Professor in the Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management towards a Doctor of Philosophy degree specialising in Transport Economics at the University of South Africa. We have funding from the University of South Africa for all study-related expenses such as fieldwork, statistical analysis technical advise and professional binding of the report for both examination and publication. We are inviting you to allow employees of the Road Traffic Management Corporation to participate in a study entitled **A hybrid framework for assessing the cost of road crashes in South Africa.**

The aim of the study is to:

- Review the most recent literature on international practices in the assessment of the cost of road traffic crashes;
- Update and compare the cost estimates of road traffic crashes in South Africa using the Hybrid Human Capital (considering 2016 as base year) and the Willingness-to-Pay approaches; and
- Recommend the most suitable approach aligned to international good practice for use in assessing the cost of road traffic crashes in South Africa.

The Road Traffic Management Corporation has been selected to participate in the study because you are directly responsible for contributing towards legislation and policy formulation as well as coming up with programmes to improve the state of road safety in South Africa. Furthermore, all the employees of the Corporation and their family members or relatives use road transport to travel for such purposes as work, education, leisure and hospital; amongst others. As a result, their participation in this study will assist in estimating the costs of road crashes that are amongst others used for cost-benefit-analysis of road safety investment options which is in line with the mandate of the RTMC.

The study will entail selected employees completing a Willingness-to-Pay survey questionnaire online. Only employees at supervisory and management levels will be required to complete the online survey questionnaire because they will be able to provide meaningful and appropriate answers to the contingent valuation and stated preference questions given their in-depth understanding and knowledge of the transport industry.

The benefits of this study are multi-fold in that consideration of the findings of this study will amongst others result in South African:

- Policy debates, road safety programmes impact analysis and resource allocation decisions that are based on up-to-date crash cost estimates;
- Road crash estimates that are comparable to those countries that have proven to be global leaders in road safety performance since estimates that will emanate from the current study will be calculated using methods that these countries use;

- Determination of the ratio of road crash estimates to the Gross Domestic Product (GDP) as well as
- Recommendations on how future crash cost estimates assessment could be improved.

There are no potential risks for employees participating in this study since the questionnaire that they will complete will not require them to provide personal information that will identify them.

Feedback procedure will entail submission of a summary of key findings of the study to the office of the Chief Executive Officer on request. A copy of the complete research report could also be made available if necessary.

Yours sincerely,

**Dr Hlengani J. Moyana**

**RESEARCHER**

## F3 Request for permission to conduct research at the Road Accident Fund

**A hybrid framework for assessing the cost of road crashes in South Africa**

23 June 2017

Dr Eugene Watson

Chief Executive Officer

Road Accident Fund

Private Bag X178

Centurion

0046

Tel.: (012) 621 1691

Email:

Dear Dr Watson,

I, Hlengani Moyana, a Divisional Head: Training and Development at the Road Traffic Management Corporation, am doing research with Professor Cine van Zyl, a Professor in the Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management towards a Doctor of Philosophy degree specialising in Transport Economics at the University of South Africa. We have funding from the University of South Africa for all study-related expenses such as fieldwork, statistical analysis technical advise and professional binding of the report for both examination and publication. We are inviting you to allow employees of the Road Accident Fund to participate in a study entitled **A hybrid framework for assessing the cost of road crashes in South Africa.**

The aim of the study is to:

- Review the most recent literature on international practices in the assessment of the cost of road traffic crashes;
- Update and compare the cost estimates of road traffic crashes in South Africa using the Hybrid Human Capital (considering 2016 as base year) and the Willingness-to-Pay approaches; and
- Recommend the most suitable approach aligned to international good practice for use in assessing the cost of road traffic crashes in South Africa.

The Road Accident Fund has been selected to participate in the study because you are directly responsible for compensating road crash victims, contribute towards formulation of road transport legislation and policy as well formulation and implementation of programmes to improve the state of road safety in South Africa. Furthermore, all the employees in the Fund and their family members or relatives use road transport to travel for such purposes as work, education, leisure and hospital; amongst others. As a result, their participation in this study will assist in estimating the costs of road crashes that are amongst others used for cost-benefit-analysis of road safety investment options which is in line with the mandate of the Road Accident Fund.

The study will entail selected employees completing a Willingness-to-Pay survey questionnaire online. Only employees at supervisory and management levels will be required to complete the online survey questionnaire because they will be able to provide meaningful and appropriate answers to the contingent valuation and stated preference questions given their in-depth understanding and knowledge of the transport industry.

The benefits of this study are multi-fold in that consideration of the findings of this study will amongst others result in South African:

- Policy debates, road safety programmes impact analysis and resource allocation decisions that are based on up-to-date crash cost estimates;
- Road crash estimates that are comparable to those countries that have proven to be global leaders in road safety performance since estimates that will emanate from the current study will be calculated using methods that these countries use;

- Determination of the ratio of road crash estimates to the Gross Domestic Product (GDP) as well as
- Recommendations on how future crash cost estimates assessment could be improved.

There are no potential risks for employees participating in this study since the questionnaire that they will complete will not require them to provide personal information that will identify them.

Feedback procedure will entail submission of a summary of key findings of the study to the office of the Chief Executive Officer on request. A copy of the complete research report could also be made available if necessary.

Yours sincerely,

**Dr Hlengani J. Moyana**

**RESEARCHER**

## F4 Request for permission to conduct research at the South African National Roads Agency Limited

**A hybrid framework for assessing the cost of road crashes in South Africa**

23 June 2017

Mr Skhumbuzo Macozoma

Chief Executive Officer

South African National Roads Agency Limited

Private Bag X415

Pretoria

0001

Tel.: (012) 844 8000

Email:

Dear Mr Macozoma,

I, Hlengani Moyana, a Divisional Head: Training and Development at the Road Traffic Management Corporation, am doing research with Professor Cine van Zyl, a Professor in the Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management towards a Doctor of Philosophy degree specialising in Transport Economics at the University of South Africa. We have funding from the University of South Africa for all study-related expenses such as fieldwork, statistical analysis technical advise and professional binding of the report for both examination and publication. We are inviting you to allow employees of the South African National Roads Agency Limited to participate in a study entitled **A hybrid framework for assessing the cost of road crashes in South Africa.**

The aim of the study is to:

- Review the most recent literature on international practices in the assessment of the cost of road traffic crashes;
- Update and compare the cost estimates of road traffic crashes in South Africa using the Hybrid Human Capital (considering 2016 as base year) and the Willingness-to-Pay approaches; and
- Recommend the most suitable approach aligned to international good practice for use in assessing the cost of road traffic crashes in South Africa.

The South African National Roads Agency Limited has been selected to participate in the study because you are directly responsible for national road infrastructure development and maintenance, contributing towards the formulation of road transport legislation and policy as well as development and implementation of programmes to improve the state of road safety in South Africa. Furthermore, all the employees in the South African National Roads Agency Limited and their family members or relatives use road transport to travel for such purposes as work, education, leisure and hospital; amongst others. As a result, their participation in this study will assist in estimating the costs of road crashes that are amongst others used for cost-benefit-analysis of road safety investment options which is in line with the mandate of the South African National Roads Agency Limited.

The study will entail selected employees completing a Willingness-to-Pay survey questionnaire online. Only employees at supervisory and management levels will be required to complete the online survey questionnaire because they will be able to provide meaningful and appropriate answers to the contingent valuation and stated preference questions given their in-depth understanding and knowledge of the transport industry.

The benefits of this study are multi-fold in that consideration of the findings of this study will amongst others result in South African:

- Policy debates, road safety programmes impact analysis and resource allocation decisions that are based on up-to-date crash cost estimates;

- Road crash estimates that are comparable to those countries that have proven to be global leaders in road safety performance since estimates that will emanate from the current study will be calculated using methods that these countries use;
- Determination of the ratio of road crash estimates to the Gross Domestic Product (GDP) as well as
- Recommendations on how future crash cost estimates assessment could be improved.

There are no potential risks for employees participating in this study since the questionnaire that they will complete will not require them to provide personal information that will identify them.

Feedback procedure will entail submission of a summary of key findings of the study to the office of the Chief Executive Officer on request. A copy of the complete research report could also be made available if necessary.

Yours sincerely,

**Dr Hlengani J. Moyana**

**RESEARCHER**

## F5 Request for permission to conduct research at the Road Traffic Infringement Agency

**A hybrid framework for assessing the cost of road crashes in South Africa**

23 June 2017

Mr Japh Chuwe

Registrar/ Chief Executive Officer

Road Traffic Infringement Agency

P O Box 6341

Halfway House

Midrand

0001

Tel.: 087 285 0500

Email: japh.chuwe@rtia.co.za

Dear Mr Chuwe,

I, Hlengani Moyana, a Divisional Head: Training and Development at the Road Traffic Management Corporation, am doing research with Professor Cine van Zyl, a Professor in the Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management towards a Doctor of Philosophy degree specialising in Transport Economics at the University of South Africa. We have funding from the University of South Africa for all study-related expenses such as fieldwork, statistical analysis technical advise and professional binding of the report for both examination and publication. We are inviting you to allow employees of the Road Traffic Infringement Agency to participate in a study entitled **A hybrid framework for assessing the cost of road crashes in South Africa.**

The aim of the study is to:

- Review the most recent literature on international practices in the assessment of the cost of road traffic crashes;
- Update and compare the cost estimates of road traffic crashes in South Africa using the Hybrid Human Capital (considering 2016 as base year) and the Willingness-to-Pay approaches; and
- Recommend the most suitable approach aligned to international good practice for use in assessing the cost of road traffic crashes in South Africa.

The Road Traffic Infringement Agency has been selected to participate in the study because you are directly responsible for the implementation of the point demerit system, contributing towards the formulation of road transport legislation, policy as well as development and implementation of programmes to improve the state of road safety in South Africa. Furthermore, all the employees of the Road Traffic Infringement Agency and their family members or relatives use road transport to travel for such purposes as work, education, leisure and hospital; amongst others. As a result, their participation in this study will assist in estimating the costs of road crashes that are amongst others used for cost-benefit-analysis of road safety investment options which is in line with the mandate of the Agency.

The study will entail selected employees completing a Willingness-to-Pay survey questionnaire online. Only employees at supervisory and management levels will be required to complete the online survey questionnaire because they will be able to provide meaningful and appropriate answers to the contingent valuation and stated preference questions given their in-depth understanding and knowledge of the transport industry.

The benefits of this study are multi-fold in that consideration of the findings of this study will amongst others result in South African:

- Policy debates, road safety programmes impact analysis and resource allocation decisions that are based on up-to-date crash cost estimates;
- Road crash estimates that are comparable to those countries that have proven to be global leaders in road safety performance since estimates that will emanate from the current study will be calculated using methods that these countries use;

- Determination of the ratio of road crash estimates to the Gross Domestic Product (GDP) as well as
- Recommendations on how future crash cost estimates assessment could be improved.

There are no potential risks for employees participating in this study since the questionnaire that they will complete will not require them to provide personal information that will identify them.

Feedback procedure will entail submission of a summary of key findings of the study to the office of the Registrar on request. A copy of the complete research report could also be made available if necessary.

Yours sincerely,

**Dr Hlengani J. Moyana**

**RESEARCHER**

## F6 Request for permission to conduct research at the Cross-Boarder Road Transport Agency

**A hybrid framework for assessing the cost of road crashes in South Africa**

23 June 2017

Mr Sipho Khumalo

Chief Executive Officer

Cross-Boarder Road Transport Agency

P O Box 560

Menlyn

Pretoria

0063

Tel.: 012 348 1357

Email: sipho.khumalo@cbrta.co.za

Dear Mr Khumalo,

I, Hlengani Moyana, a Divisional Head: Training and Development at the Road Traffic Management Corporation, am doing research with Professor Cine van Zyl, a Professor in the Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management towards a Doctor of Philosophy degree specialising in Transport Economics at the University of South Africa. We have funding from the University of South Africa for all study-related expenses such as fieldwork, statistical analysis technical advise and professional binding of the report for both examination and publication. We are inviting you to allow employees of the C-BRTA to participate in a study entitled **A hybrid framework for assessing the cost of road crashes in South Africa.**

The aim of the study is to:

- Review the most recent literature on international practices in the assessment of the cost of road traffic crashes;
- Update and compare the cost estimates of road traffic crashes in South Africa using the Hybrid Human Capital (considering 2016 as base year) and the Willingness-to-Pay approaches; and
- Recommend the most suitable approach aligned to international good practice for use in assessing the cost of road traffic crashes in South Africa.

The C-BRTA has been selected to participate in the study because you are directly responsible for cross boarder movement of people and goods, contributing towards the formulation of road transport legislation and policy as well as development and implementation of programmes to improve the state of road safety in South Africa. Furthermore, all the employees of the C-BRTA and their family members or relatives use road transport to travel for such purposes as work, education, leisure and hospital; amongst others. As a result, their participation in this study will assist in estimating the costs of road crashes that are amongst others used for cost-benefit-analysis of road safety investment options which is in line with the mandate of the C-BRTA.

The study will entail selected employees completing a Willingness-to-Pay survey questionnaire online. Only employees at supervisory and management levels will be required to complete the online survey questionnaire because they will be able to provide meaningful and appropriate answers to the contingent valuation and stated preference questions given their in-depth understanding and knowledge of the transport industry.

The benefits of this study are multi-fold in that consideration of the findings of this study will amongst others result in South African:

- Policy debates, road safety programmes impact analysis and resource allocation decisions that are based on up-to-date crash cost estimates;
- Road crash estimates that are comparable to those countries that have proven to be global leaders in road safety performance since estimates that will emanate from the current study will be calculated using methods that these countries use;

- Determination of the ratio of road crash estimates to the Gross Domestic Product (GDP) as well as
- Recommendations on how future crash cost estimates assessment could be improved.

There are no potential risks for employees participating in this study since the questionnaire that they will complete will not require them to provide personal information that will identify them.

Feedback procedure will entail submission of a summary of key findings of the study to the office of the Chief Executive Officer on request. A copy of the complete research report could also be made available if necessary.

Yours sincerely,

**Dr Hlengani J. Moyana**

**RESEARCHER**

## F7 Request for permission to conduct research at the Railway Safety Regulator

**A hybrid framework for assessing the cost of road crashes in South Africa**

23 June 2017

Mr Nkululeko Poya

Chief Executive Officer

Railway Safety Regulator

P O Box 655

Bruma

2026

Tel.: 012 348 1357

Email: nkululekop@rsr.org.za

Dear Mr Poya,

I, Hlengani Moyana, a Divisional Head: Training and Development at the Road Traffic Management Corporation, am doing research with Professor Cine van Zyl, a Professor in the Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management towards a Doctor of Philosophy degree specialising in Transport Economics at the University of South Africa. We have funding from the University of South Africa for all study-related expenses such as fieldwork, statistical analysis technical advise and professional binding of the report for both examination and publication. We are inviting you to allow employees of the RSR to participate in a study entitled **A hybrid framework for assessing the cost of road crashes in South Africa.**

The aim of the study is to:

- Review the most recent literature on international practices in the assessment of the cost of road traffic crashes;
- Update and compare the cost estimates of road traffic crashes in South Africa using the Hybrid Human Capital (considering 2016 as base year) and the Willingness-to-Pay approaches; and
- Recommend the most suitable approach aligned to international good practice for use in assessing the cost of road traffic crashes in South Africa.

The RSR has been selected to participate in the study because you are directly responsible for regulating railway safety which also includes level crossings which is the point where rail rolling stock and road transport fleet meets, contributing towards the formulation of road transport legislation and policy with regards to level crossings as well as development and implementation of level crossing related programmes to improve the state of road safety in South Africa. Furthermore, all the employees of the RSR and their family members or relatives use road transport to travel for such purposes as work, education, leisure and hospital; amongst others. As a result, their participation in this study will assist in estimating the costs of road crashes that are amongst others used for cost-benefit-analysis of road safety investment options which is in part in line with the mandate of the RSR.

The study will entail selected employees completing a Willingness-to-Pay survey questionnaire online. Only employees at supervisory and management levels will be required to complete the online survey questionnaire because they will be able to provide meaningful and appropriate answers to the contingent valuation and stated preference questions given their in-depth understanding and knowledge of the transport industry.

The benefits of this study are multi-fold in that consideration of the findings of this study will amongst others result in South African:

- Policy debates, road safety programmes impact analysis and resource allocation decisions that are based on up-to-date crash cost estimates;
- Road crash estimates that are comparable to those countries that have proven to be global leaders in road safety performance since estimates that will emanate from the current study will be calculated using methods that these countries use;

- Determination of the ratio of road crash estimates to the Gross Domestic Product (GDP) as well as
- Recommendations on how future crash cost estimates assessment could be improved.

There are no potential risks for employees participating in this study since the questionnaire that they will complete will not require them to provide personal information that will identify them.

Feedback procedure will entail submission of a summary of key findings of the study to the office of the Chief Executive Officer on request. A copy of the complete research report could also be made available if necessary.

Yours sincerely,

**Dr Hlengani J. Moyana**

**RESEARCHER**

## Appendix G: Ethics clearance certificate

UNISA university of south africa

Ref #: 2017_CEMS_ESTTL_010

25 August 2017

**DEPARTMENT OF ENTREPRENEURSHIP, SUPPLY CHAIN, TRANSPORT, TOURISM AND LOGISTICS MANAGEMENT RESEARCH ETHICS REVIEW COMMITTEE**

This is to certify that the application for ethics clearance submitted by
Mr Hlengani Jackson Moyana (student number 3058 6895, 30586895@mylife.unisa.ac.za)
"A hybrid model for assessing the cost of road crashes in South Africa"
**received Ethics Approval**

The application for ethics clearance for the above mentioned research was reviewed (as an expedited review) by the Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management Research Ethics Review Committee in August 2017 in compliance with the Unisa Policy on Research Ethics. Ethical Clearance for the project is granted. You may proceed with the research project.

The research ethics principles outlined by the Unisa Policy on Research Ethics must be adhered to throughout the project. Please be advised that the committee needs to be informed should any part of the research methodology as outlined in the Ethics application (Ref #2017_CEMS_ESTTL_010) change in any way or in case of adverse events. This certificate is valid for one year from date of issue. The ESTTL Research Ethics Review Committee wishes you all the best with this research undertaking.

Kind regards,

Poole

**Mrs C Poole**
**Chairperson**

**Executive Dean: CEMS**

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

## Appendix H: 2016 RTMC unit road traffic costs by cost category and cost element

| Cost element | Unit cost per RTC (Rand) | | | | |
|---|---|---|---|---|---|
| | Fatal | Major | Minor | Damage only | Any severity |
| Human casualty | | | | | |
| Lost productivity | 2 878 177 | 217 253 | 29 504 | 2 094 | 55 331 |
| Pain, grief, suffering and lost quality of life | 2 123 994 | 287 173 | 47 509 | | 49 842 |
| Medical treatment | 147 143 | 110 656 | 32 681 | | 12 509 |
| Funeral | 16 613 | | | | 222 |
| Work place re-occupation | 68 638 | 2 949 | | | 1 061 |
| Sub-total: human casualty cost | 5 234 565 | 618 031 | 109 694 | 2 094 | 118 965 |
| Vehicle repair | | | | | |
| Vehicle repair | 19 604 | 20 171 | 21 887 | 26 822 | 25 618 |
| Sub-total: Vehicle repair cost | 19 604 | 20 171 | 21 887 | 26 822 | 25 618 |
| Incident | | | | | |
| Emergency response | 3 042 | 2 765 | | | 174 |
| Legal | 101 623 | 101 623 | | | 6 258 |
| Vehicle related | 3 107 | 3 197 | 3 469 | 4 251 | 4 060 |
| RTC management | 10 176 | 5 101 | 2 030 | 2 030 | 2 287 |
| Infrastructure damage | 1 596 | 1 637 | 2 023 | 2 508 | 2 376 |
| Delay congestion and emissions | 61 547 | 13 140 | 13 140 | 10 829 | 11 987 |
| Sub-total: Incident cost | 181 092 | 127 462 | 20 662 | 19 618 | 27 143 |
| **Total unit cost** | **5 435 261** | **765 664** | **152 244** | **48 533** | **171 727** |

(Labuschagne, 2016:35)

## Appendix I: Total road traffic crash costs by cost category and cost elements: 2016

| **Cost category** | **Total cost per RTC (R million)** | | | | | |
|---|---|---|---|---|---|---|
| | **Fatal** | **Major** | **Minor** | **Damage only** | **Total** | **%** |
| Human casualty cost | 58 332 | 24 794 | 14 546 | 1 358 | 99 030 | 69.3 |
| Vehicle repair cost | 218 | 809 | 2 902 | 17 395 | 21 326 | 14.9 |
| Incident cost | 2 018 | 5 113 | 2 740 | 12 723 | 22 595 | 15.8 |
| **Total cost** | **60 569** | **30 716** | **20 189** | **31 477** | **142 951** | **100.0** |
| **Per cent** | 42.4 | 21.5 | 14.1 | 22.0 | 100.0 | |

(Labuschagne, 2016:36)

## Appendix J: Total road traffic crash cost by cost type, category and element (rand): 2016

| Cost element | Internal (uncompensated victim) | External (private) (uncompensated others) | External (public sector) (uncompensated public) | Insurance (private) (compensated victim & others) | Total |
|---|---|---|---|---|---|
| **Human casualty** | | | | | |
| Lost productivity | 34 528 657 739 | 6 017 632 169 | | 5 513 262 664 | 46 059 552 571 |
| Pain, suffering and lost quality of life | 35 121 533 212 | 4 390 191 652 | | 1 978 009 509 | 41 489 734 373 |
| Medical treatment | | | 9 354 315 159 | 1 058 420 917 | 10 412 736 076 |
| Funeral | 157 329 394 | | | 27 796 615 | 185 126 008 |
| Work place re-occupation | | 883 185 558 | | | 883 185 558 |
| Sub-total: Human casualty cost | 69 807 520 344 | 11 291 009 379 | 9 354 315 159 | 8 577 489 705 | 99 030 334 587 |
| **Vehicle repair** | | | | | |
| Vehicle repair | 12 334 550 509 | | | 8 991 026 648 | 21 325 577 157 |
| Sub-total: Vehicle repair cost | 12 334 550 509 | | | 8 991 026 648 | 21 325 577 157 |
| **Incident** | | | | | |
| Emergency response | | | 24 403 256 | 120 434 791 | 144 838 047 |
| Legal | | | | 5 209 274 099 | 5 209 274 099 |
| Vehicle related | | | | 3 379 716 014 | 3 379 716 014 |
| RTC management | | | 1 903 953 544 | | 1 903 953 544 |
| Infrastructure damage | | | 1 978 138 540 | | 1 978 138 540 |
| Delay congestion and emissions | | 9 978 752 945 | | | 9 978 752 945 |
| Sub-total: Incident cost | | 9 978 752 945 | 3 906 495 340 | 8 709 424 905 | 22 594 673 190 |
| **Total cost** | **82 142 070 853 (57% of total)** | **21 269 762 323** | **13 260 810 499** | **26 277 941 258** | **142 950 584 934** |

(Labuschagne, 2016:38-9)

## Appendix K: Cluster analysis results

### Clusters

Input (Predictor) Importance

1.0 0.8 0.6 0.4 0.2 0.0

| Cluster | 1 | 2 |
|---|---|---|
| Label | | |
| Description | | |
| Size | 69.7% (145) | 30.3% (63) |
| Inputs | 1.7. Involved in Motor vehicle accident Yes (95.9%) | 1.7. Involved in Motor vehicle accident No (100.0%) |
| | Injuries as a result of motor vehicle accident No (70.3%) | Injuries as a result of motor vehicle accident Not applicable ... |
| | 1.2. Gender Male (63.4%) | 1.2. Gender Female (55.6%) |
| | 1.3. Age 35 - 44 (45.5%) | 1.3. Age 35 - 44 (49.2%) |
| | 1.11. Main purpose of travel Compelling reasons (work, studies, ... | 1.11. Main purpose of travel Compelling reasons (work, studies, ... |
| | 1.5. Car or vehicle ownership More than one car or vehicle (57.9%) | 1.5. Car or vehicle ownership More than one car or vehicle (65.1%) |
| | 1.9. Hours travelled per day 1 - 2 hours (54.5%) | 1.9. Hours travelled per day 1 - 2 hours (61.9%) |
| | 1.10. Level of anxiety Moderately worried (37.2%) | 1.10. Level of anxiety Moderately worried (34.9%) |
| | 1.4. Education Degree (44.1%) | 1.4. Education Degree (47.6%) |
| | 1.12. Mode of transportation Private car (96.6%) | 1.12. Mode of transportation Private car (96.8%) |
| | 1.6. Income More than 80 000 (28.3%) | 1.6. Income More than 80 000 (25.4%) |